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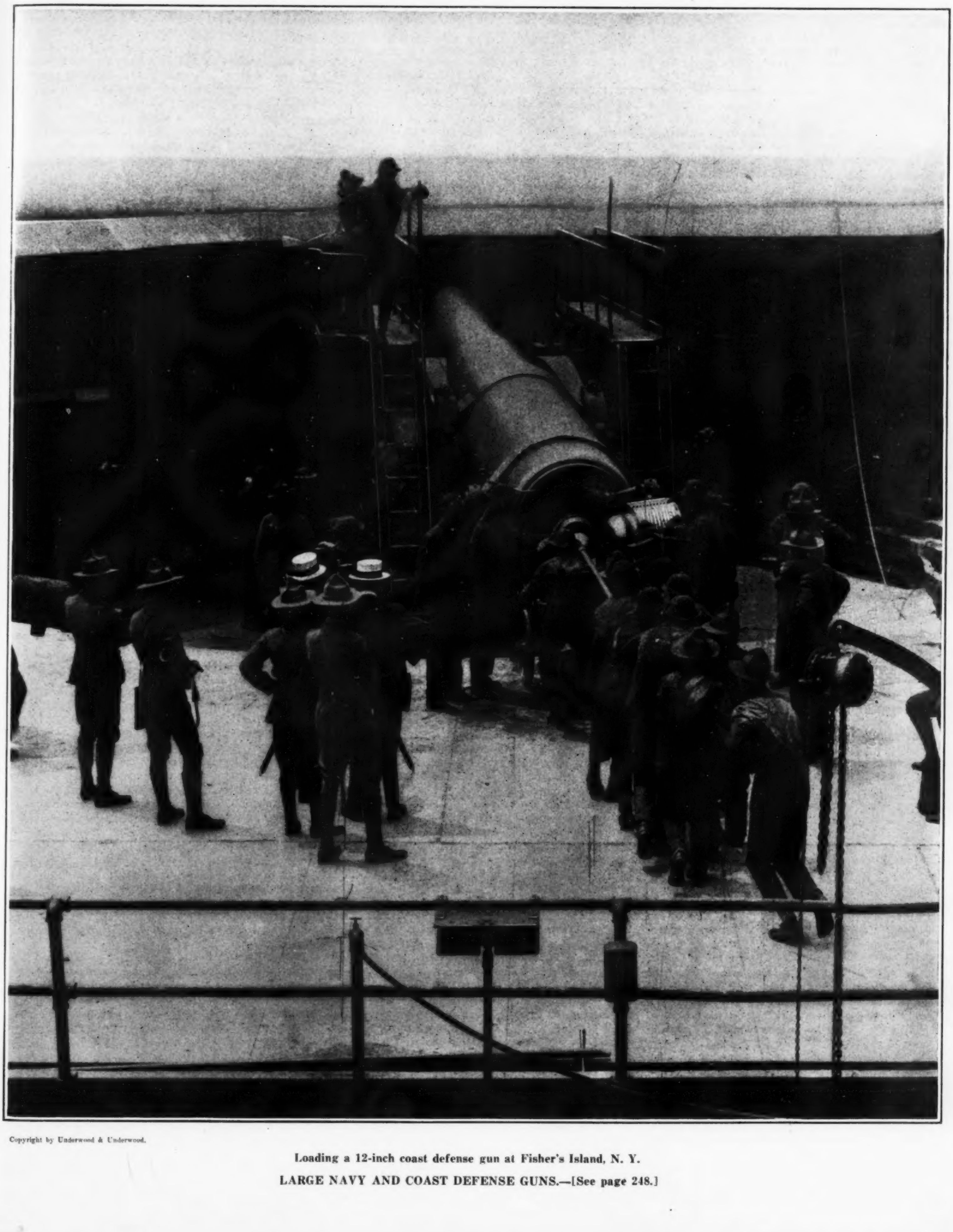

Loading a 12-inch coast defense gun at Fisher's Island, N. Y.

LARGE NAVY AND COAST DEFENSE GUNS.—[See page 248.]

Economy in Study

Observation and the Taking of Notes

By Prof. George Van N. Dearborn, A.M., Harvard, MD., Ph.D., Columbia

[*"Economy in Study," published in this magazine July 17, 1915, seemed to be so useful that the author has arranged to extend the suggestions contained therein. We publish to-day the first instalment of these practical hints.*—EDITOR.]

I WISH first of all to point out to you that education as well as being a theoretically precious and a thoroughly practical thing, is in fact also a good *financial* investment. Some one has suggested that the uneducated man earns about $1.50 per day, or $20,000 in forty years; a high-school graduate about $1,000 a year, or $40,000 in forty years; a college man earns on an average say about $3,000 per year, or $120,000 in forty years, when an average amount of work is done. The difference between the first and second is $20,000, but the difference between the second and the third, between the earnings of the high school and the college graduates, is *$80,000*. That is a whole fortune in itself. These statements point out more practically and more explicitly than others the material value of an education to those numerous people who measure all things for the most part in terms of dollars and cents.

Huxley's definition of a liberal education is as follows: "That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold logical engine, with all its parts of equal strength, and in smooth working order; whose mind is stored with a knowledge of the great and fundamental truths of nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to a halt by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to love others as himself. Such a one and no other has had a liberal education."

That is in my opinion at once the most scientific and the generally best definition of an education that was ever written, and therefore is worth repeating continually. I wish, however, to call attention to one statement there and to show how to some extent it is mistaken. This definition says "whose intellect is a clear, cold logical engine, with all its parts in smooth working order," etc. One of the leading physiological psychologists of the world in the very broad and untechnical sense, Huxley here undoubtedly expressed a hope rather than a statement of fact. The epidemic of mental and physical "testing" from which America is now suffering has served, among other ends, to emphasize anew that the mind cannot, and indeed should not, be what Huxley has suggested above. Very recently Morton Prince, the world's most eminent authority on the subconscious aspects of mind, writes in a remarkable essay on "The Psychology of the Kaiser": "Our conscious thoughts are much more determined by subconscious processes, of which we are unaware, than we realize. One great popular delusion is that our minds are more exact logical instruments than they really are, and we stand in awe of the minds of great men, thinking that because they are superior in certain directions therefore they are superior in all other directions of their activities, where they claim superiority. Whereas, as a matter of fact, a man may be eminently superior in certain fields of mental activity and psychologically a perfect fool-thinker and fool-performer in other fields. Helmholtz said of the eye that it was such an imperfect optical instrument that if an instrument-maker should send him an optical instrument so badly made, he would refuse to accept it and return it forthwith. He might have said the same thing of the human mind. It is a very imperfect instrument of thought. All we can say is that it is the best we can get. The deeper insight we get into the mechanism of the human mind, the poorer thing it appears as an instrument of precision."

It is only man's instinctive egotism on one hand, uncorrected by his relative ignorance on the other, that has kept this, the obviously correct attitude, from long since becoming common wisdom. One who knows he has to work with poor tools will see all the more occasion and necessity for all the information and hints he can obtain, and for the exercise both of the greatest diligence and the greatest care in using them. It is well to realize that the body and the mind educationally speaking are tools, tools none too efficient which have to be *trained* into high ability. The mind is in general a capable instrument, but not particularly so as an instrument of precision.

It is well worth while for every student to be *economical in the use of time*, to learn in the most economical manner that he can. That is my chief sanction for offering you as an important matter the more economical methods of study and of learning.

We do not need, even as an introduction, to discuss at all the nature of education, and we shall not do so. But I do suggest that a good short definition of the essence of human education is the *reaction of personality to its environment*. The "reaction" in this definition is for our immediate practical purpose the important thing.

The learning process, it must be remembered, is not a material process. One could not give you knowledge of literature, of geometry, of physics, etc., as one might readily give the detailed directions for the successful construction of a chocolate cake, or for the building of a complete doll's house. The two problems are distinctly different. The best that one can do in giving advice on such a matter as learning, so subtle, and so abstract at times, is to state the chief effective conditions involved as simply as possible, and then to trust implicitly (as surely we properly may do) in the natural action of the learner's mind on the information secured.

Indispensable, certainly, for learning worthy its high reputation, is the *consistent, deeply seated will-to-learn.* One must firmly impress his motivation force and set it in permanent action. The process cannot indeed be mechanically described, for this will-to-learn must do its own work, secure its own victories over ignorance and inadequacy. In other words, the student, whatever knowledge be his subject, must have a real and lasting desire to learn.

Learning is not the mere filling of a barrel with apples, but the slow-growing of both the barrel and the apples from the seedlings up. But we may note that out of the five or six million people in the United States who cannot read or write, some have never seen the guide-board, do not even know where or how they wish to go! These certainly would not wish to be whisked along in a limousine; nor should you.

With an ever and ever opening vista, further and further on into the depths of reason and reality, the cosmos of spirit and of "matter" opens to the persistent and the serious student. The relation between the cosmos and your minds is dependent largely upon the process of *observation*, including the observing of your own minds. The term observation suggests an important element of learning; in fact, learning is unthinkable without it, especially perhaps in the natural sciences, of which there are many. Observation is obviously a form of note-taking; it is taking notes and writing them "on the tablets of your memory" or brain instead of on paper.

There are two kinds of observation. First, there is a primary knowledge of nature outdoors, and under somewhat artificial conditions in the laboratory; and, second, secondary observation of books and of other, e. g., pictorial, descriptions of original observation. Both of these forms of observation furnish material for note taking.

Direct observation requires a habit of the continually sensitive and accurate use of the sense organs; organs of movement, sensation, of hearing, of touch, smell, heat and cold, sometimes singly, but sometimes too all at once.

Observation should be always explicit; in fact unless it be explicit, it is not observation at all, but a form of wool gathering. In many cases it must be minutely explicit in order to be of any value. Details often lend things a new aspect, details which have not before been noticed, and thus lead sometimes to important discoveries. All of this process of observation involves a fine adjustment (by means of muscles and nerves and sometimes glands) of the sense organs. Trifles make perfection, but perfection is no trifle, and thus it is in this phase, the detailed phase of observation. But on the other hand, observation must be also a process of observing things in their entirety and in the general relation to environment. One must not miss the ocean's grandeur for study of the waves upon the shore, any more than one ought to miss the beauty of a forest because of the crowded trees. There is chance for observation in street-cars and trains! Travel supplies the material for observation and the stimulus to use this power. Observation exercises one's mind, while the travel tones one up and rests one's organism. In general terms, however, direct observation is incompatible with book-study because it distract's one's interest therefrom. This is one of the difficulties of travel, as used to be the mode, in order to study; one forgets to study, and naturally is it so.

Another matter: *this habit of minute adjustment of the senses involves a disregarding of whatever is already familiar*, so that, in a way, for effective observation you have to be really familiar with whatever you think you are familiar with; which is to say, you really have to mind your P's and Q's.

Interest is absolutely necessary. Observation depends on interest, and with interest the observation process becomes automatic and therefore easy.

There is a great amount of labor required in real observation. It is not a passive process, but on the other hand requires much effort, much bodily activity, the details of which are too technical for discussion even in this preliminary sketch of the nature of observation. This process of sensory adaptation is called perception. A perception is an active reaction to some object around and requires many fine muscular adjustments.

Sense-training of the simplest sort is one of the most important of all the elements of education, but for the most part only the feeble-minded children, under the system of Seguin and Fernald, have the advantages of it. But no one is too old to develop a greater efficiency in this, the very basis of intelligence. The elementary educational system is at fault to omit this, whatever else it might have to omit to give it room. Natural sense-training comes from natural interests, but it is only a fraction of what it might become. Few people yet realize how utterly different things and events appear to different observers even under practically the same conditions precisely. Prof. J. McKeen Catell of Columbia made some striking demonstrations of this difference years ago. A two-colored quadrangular card was exposed to a dozen or two intelligent persons for a short time, and when the drawings of what each "subject" saw were compared it was found that only two perceived the square red-and-white area alike, and these not exactly so, despite the mere chance of similarity.

Thus one has to learn to observe much as one has to learn to become skillful. Skill is the same process as accurate sense perception; and voluntary attention is another process which involves perfect and general bodily control. This must be taken in a general and broad sense of bodily fitness and includes at least five fundamental states and processes. First, it involves vigor; it involves a good deal of initiative; it involves mental quickness (wit) and sensitivity to every educating influence; and, fifth, self-confidence. Intelligence itself (which is only a larger name for skill) is but a fine adaptation to and appreciation of one's effective environment, spiritual and material. Skill in its essence is a cursive general voluntary power to finely adjust the muscles, those used in the adaptations of the sense organs especially, in some cases. Since there is no mental process without muscular innervation skill is obviously closely allied to intellect—even though the syllogism here be imperfect. More than a hundred years ago the famous Pestalozzi said, "Keine Kenntniss ohne Fertigkeit": no learning without skill. The whole relation of the mind and body is involved in an actual demonstration of this proposition; but it certainly can be accomplished. Skill is potential imagination of the practically constructive sort, and this we shall discuss, as a means to easy learning, in a later lecture.

Prof. Muensterberg of Harvard offers much wisdom in this matter in one of his recent books: "We cannot emphasize too much the similarity between the external and the internal actions, between the movements of the limbs and the movements of the thoughts. To remember, to invent, to attend, to observe, to reason, means above all to adjust inner impulses to the final aim, to suppress and inhibit those which interfere and to excite and reinforce those which lead forward. The training in external actions is practically the model process for the training in all psychical abilities.

Prof. J. B. Watson of Johns Hopkins is at present engaged in elaborate research which will greatly extend the work of von Bechterew in Petrograd, and will show anew how easily made are many highly useful bodily associations through the extremely adaptive system of nerve units

Such easily formed new associations constitute the

bodily basis, in part, of those numberless sets of delicate adjustments of the muscles and glands and sense organs on which that capability depends, which, lacking a better word, we have termed *skill*. No constructive mental process, i. e., no learning, is possible without this marvelous ease of association-sets between the numerous different muscles and sense organs of the learner, and between the learner as an individual and his surroundings or "environment" both of a material nature and of the kind we term spiritual or mental.

Nowhere are these hints as to the motor basis of mental processes, e. g., learning, more appropriate than for the practice of observation. It must be noted, however, for future reference, that these same principles of facilitation will be applicable repeatedly in different phases of our counsel on easy learning—in imagining, in studying, in reading, in thinking, in preparing for examination and in actually performing this climax of educative cruelty.

More specifically for observation, however, and reduced to untechnical terms, expert *observation requires concentrated attention* (muscular adaptation under fine voluntary control) *to the entire object or process under observation, both as to its details and its influencing surroundings.* In other words, there must be adequate realization of the real nature of the object observed, and adapted attention to both its internal and its external relations. Such attention, based on knowledge, would seem to afford the best chance of the observation process being efficiently productive of things new, either to the individual or to the world as well. One might almost, though with some risk, concentrate the practical advice into *informed, concentrated attention to the object and its relations.*

Laboratory work, shop work, studio work, field work, and all the other familiar factors in present day practical education are of course but systematized material for first-hand observation. In some professional schools it has probably gone too far, but in no elementary school the world over has it gone nearly far enough—if we exclude the kindergartens. Laboratory work makes *massive* the facts and the principles of science, fills them out and makes them solid and substantial so that they really affect the mind. For all laboratory work a practical point of advice is, *follow the directions exactly, and keep detailed and thoughtful notes of what you particularly observe and learn* in this practical manner. My experience in the psychological and physiological laboratories has been that that is the first definite step toward success, but I find that many students do not follow the directions accurately enough to be well guided in their work. Practical work is highly specialized and very complex; so do not fail to follow the directions exactly, all the while thinking how to develop the work. Do no experiment save as a demonstration of some principle or of some extra-important fact. That is, do no mechanical work in a purely mechanical way. Most experiments done in a laboratory, or in field work, are intended solely as demonstrations of some underlying principle, and if done in a mechanical way the exercise is worse than doing nothing at all and is idle and waste. When true and thoughtful observation can be thereby obtained, laboratory work is the most rapidly developing of all kinds of study.

Doctor J. E. Mayman of New York University reports: "On the basis of efficiency as measured by percental attainments, by lasting impressions on the minds of elementary school pupils, by persistence in memory, by encouragement of independent thought and self-reliance, and by popularity among the pupils the three methods rank as follows: First, experimental method; second, lecture method; third, book method. On the basis of minimal time consumption in the actual teaching of the lessons, of arousing and holding interest and attention, and of the minimal expenditures of mental and physical energy, they rank as follows: First, lecture method; second, experimental method; third, book method."

So much as to the taking of notes on the tablets of your memory. Next, as to the taking of notes on paper or (in the case of youthful remote pupils) on the slate.

It has been said sometimes even by university professors of some subjects, Do not take notes, but train your minds! Now this viewpoint is all right and perfectly sanctioned by psychology, provided, always provided, that you go home or to your room immediately and run over in several good text-books the very topic that you have just heard about in the lecture or recitation. The same thing may be accomplished by discussing a lecture with a party of fellow students. Otherwise, in almost all modern subjects, the taking of notes is absolutely essential. And these conditions are very seldom met with in practice. In the first place, only a few students have a sufficiently complete list of text-books on any one subject; and quite as few have the time or the occasion to review and discuss the topic or subject immediately after its presentation. Therefore the taking of notes would be one of expediency and is on the whole the best practical means. On certain subjects even the suggested review either in text-books or by conversation, would be quite inadequate. Of a lecture on materia-medica, for example, in which large numbers of compounds are discussed, only a small fraction could be retained by any one, or in any event at a wholly improper expenditure of nervous energy. The objections to note-taking were more reasonable two hundred years ago than they are now, for a century or two ago a man of intelligence and diligence could learn pretty much everything valuable that there was to be learned. A man in a few years could learn all the science and a considerable part of the literary knowledge of the entire world. On the other hand, to-day science and learning in general are so divided up into specialties that no man can learn more than one per cent of the world's substantial knowledge in a life-time. Hence written notes must be taken so that they may be kept and their details and endless inter-relations conned and learned at leisure outside the lecture or the recitation room.

Another point is that the memory is not developable. You cannot develop your memory. It is not like an ample chest or a good disposition, but it is more like a big foot or a large ear; you are born with it and it cannot ordinarily be improved. One can train the *use* of one's memory, but it has been demonstrated that to train the span of retention practically is impossible. Memory is a birth gift—you have a good memory or a bad memory and you can learn how to use it. Notes then become, first, practically essential, and in part too because of the economy of nerve force which the taking of notes implies. We should not be guided in practice by what at any cost we can do: it is what we can do *economically* that counts as of most value. It is not a matter, for example, in the matter of exposure, of whether you are safely to run risks of getting pneumonia, but it is a matter of whether it is expedient or unwise to run this risk. It is economy to stay in the house for a few days whenever you have a bad infectious cold. So, in principle, it is with nerve expense.

Second, notes are essential as a means to the formation of the habit of logical thought. It is essential that you should record your notes so that the facts and principles in them are arranged in a systematic and in an accurate and concise way. Thus done, the taking of notes is the quickest way to put your mind in like logical order.

Lectures, again, are full of facts and so are text-books, and one of the surest ways of providing your subconscious mind with ideas to use is a systematic arrangement of ample notes and the frequent abstracting of them. In this manner (probably through the motor activities required by the writing process) the brain is impressed by a series of motor pathways as well as by a relatively ample number of sensory pathways. An important factor in note taking is that they should be arranged scientifically, and that means logically, for example, like the adequate table of contents of an elaborate, printed scientific book. The mind works continually on the principles of symbols and of complexes (see below), and notes are the best possible means of providing economical food to the brain and the mind. One should have center headings, side headings, inter lines, and, in many cases, the use of different colored crayons for the impression of this essential logical sub-division. These means represent the many different sizes of type and type faces (italics and roman) in a printed book.

A notebook should be made of large pages, loose pages preferably, and unruled, so that you are not confined to hand-writing of a certain size. If you have unruled paper you have not only a chance for much more freedom in that respect, but a chance also for pictures. An 8½-inch by 11-inch notebook is an ideal notebook. Pocket notebooks are extremely important. Take a notebook with you wherever you go, if you are ambitious to learn broadly and accurately as the years go past. The one which I am carrying to-day I see is No. 25 of my series, meaning that twenty-four have been filled with small writing of facts of innumerable kinds, I cannot tell whence. These "commonplace books" in a way serve as a history of your education. In the taking of notes the use of abbreviations is of the utmost importance. Develop easily a code of your own; shorthand is almost indispensable for the student, but you can easily develop a useful system of abbreviations of your own much more quickly than you realize, and in the passing years they will save much time. These abbreviations are for the purpose of saving time, not paper—paper is not an important factor. A good fountain pen can be had for 60 cents. In lieu of a fountain pen, use plenty of soft pencils; and acquire the habit of using colored grease crayons.

Diagrams are sometimes of immense importance in the taking of notes; they are of value as much in some cases according to their simplicity as in others according to their complexity; so you must not refuse to copy a diagram put before you because "you cannot draw." You acquire the habit of drawing diagrams much faster than you realize, and each one expresses much to your associative mind. The making of graphs is of great importance because a graph oftentimes expresses more than could whole pages of technical description.

Reviewing your notes is of much importance. Prof. H. A. Peterson of the Illinois State Normal University read in the recent psychological meetings at the University of Chicago a paper on the measured effects of reviewing.

"The results so far are: After three weeks the one-review group recalls 1.89 times as much as the no-review group. After six weeks the one-review group recalls about 1.33 times as much as the no-review group, and after eighteen weeks the superiority of the former has sunk to about 25 per cent. After six weeks the two-review group recalls about twice as much as the no-review group, and after eighteen weeks the former recalls 1.8 times as much as the latter.

"While the reviews here used were undoubtedly thorough, the results probably exceed the most common expectations. While the effect of the review, like that of the first learning, decreases rapidly at first, and later more slowly, a substantial residue remains after the sixth week. All of the results were obtained from the use of a single historical selection of only moderate difficulty."

The reason for these results we do not need to discuss in detail. They depend on the principles of habit formation, that universal process underlying all that lives which we shall have need of considering briefly later on in sundry connections.

Laboratory notebooks are extremely important in your education. They are so especially because they constitute the records of *discovery and research* so far as you are concerned. Laboratory or field work on nature at first hand, so far as you are concerned, really is research and discovery, no matter if the facts have been discovered by others before you.

Notes nearly always should be *in your own words*. Otherwise they are "cribs" and properly not notes at all, for your mind's use. A good lecture is explanation and not dictation of a set of cribs; not description, but explanation. In some schools there is far too much lecturing, and far too little studied review of text-books by means of recitation. The same is equally true of books as of lectures. Notes are of no real educative use to you unless or until they have been sufficiently worked over in your own mind as to be readily expressed in your own words. Therefore the importance of using your own English. There is no way so good as taking notes just as you would talk them to a little sister seven years old at home.

The subconscious mind fuses and retains the facts on the principles of symbolic action, and elaborates them. That is one of the important reasons for taking adequate notes. Each note should serve as a symbol by which the mind (and nervous system) can get hold of it and connect it for use with other facts and other principles.

You should keep your notes always posted up. I do not mean summarized daily in writing, but I do mean posted up in your brain. Notes which are not reviewed become dead notes (rots) in a few days. It is not really necessary to summarize your notes in writing in your notebook, but in so keeping them posted up you train the mind to be always abstracting. Make your notes as you would like your mind to be: First, *abundant*; second, *accurate*; third, *logical*, and fourth, *free*.

Another thing worth considering perhaps is the importance and practical value of *preserving* your notebooks, the same being true of your textbooks. In the first place, they often are practically useful to you later on in your career. I suspect that many of the courses given by students soon after leaving school are practically the reproduction of the lectures which they have had in school. Second, good notes are part of your mind just as your mother and your sweetheart and your childhood home are parts of your personality (see James's "Me"). More than that, your sons and daughters probably will value them at some future time!

Another important thing in the taking and the learning of notes is the *forgetting* of things which should be forgotten. It has been said by psychologists that forgetting is only less important than remembering. By glancing over your notes you may select the important things and neglect the dead and adynamic things which are to be passively forgotten. Nothing once impressed, it seems, ever leaves the brain save by gross loss of cerebral tissue; the impression continues during life. What we actually have in our working minds is then only a small fraction of what in some mysterious manner is impressed in our brains. So it is true that only a relatively small portion of the notes can properly be remembered; the rest may be forgotten. Some things are quick and become active agents in our education; but some, too, are wholly dead for us, and are (and should be) lost out of our effective minds.

Animals With Many Eyes*

Varied and Curious Organs of Special Development

By Stanley C. Bailey, A.M.I.C.E., F.G.S.

The embryological development of the eyes of vertebrates shows that they are formed by a coalescence of two sets of structures—namely, an involution or ingrowth of the skin, and a corresponding outgrowth of the brain.

At first two pear-shaped bodies grow outward and downward from the brain, the bulbous portion being in front, until they meet the skin, they then become egg-cup shaped, their stems being connected to the brain, a hollow forms in the skin at the points of contact with the brain outgrowths, the skin then thickens and folds on itself, at the same time growing inward into the cups, and becoming solid, thus developing into the crystalline lens; the edges of the cup-shaped outgrowths grow over to the edges of the lens, and a covering forms over the whole eye, which becomes nearly globular in shape, the iris and cornea arise from portions of this covering, and so the complete eye is formed, its interior being filled with a transparent gelatinous substance called the corpus vitreum or vitreous humor, while between the cornea and the lens there is a watery fluid known as the humor aqueous or aqueous humor.

But in the invertebrates and insects the eyes appear to have been derived by modifications in the epidermal or outer cells of the skin, and have been formed by an ingrowth of the skin cells toward the brain, or bundles of ganglia, which correspond to the brain in vertebrates.

Most insects have a pair of large compound or faceted eyes, and often there are groups of ocelli, stemmata, or single eyes on the top of the head. The compound eyes are in reality masses of ocelli, often numbering many thousands, which are closely packed together, and the facets of which are sometimes circular or square, but more often regular hexagons in shape, or modifications of the hexagonal form.

There are no lenses similar to those of vertebrates; but each of the facets of the compound eye forms the base of a transparent pyramid, the facets corresponding to the cornea of the vertebrate eye; the apex of each pyramid is directed inward toward the brain, and is connected to a transparent calyx or cup; there is a nerve to each pyramid, and all the nerves are joined to a ganglion in contact with the brain, or bunches of ganglia, the spaces between the pyramids are filled with coloring matter or purple pigment granules; but in some insects the coloring matter is either red, yellow, or green. The pyramids are also filled with a fluid which is usually transparent, and there are retinulæ that correspond to the rods and cones at the back of the retina of eyes of vertebrates.

In crustaceans and arachnids the eyes are formed in a similar way to those of insects, except that in the Arachnida, such as spiders and scorpions, there are no compound eyes, only groups of ocelli or single eyes.

It has been thought that insects do not see so clearly as vertebrates, but look at things as if through a veil, being able to distinguish between light, shade, and color only. As an instance of this, it should be noted that butterflies, moths, and some flies may be easily caught in the fingers, provided the shadow cast by the hand does not pass over their bodies. On the other hand, the groups of single eyes in spiders, although they resemble the ocelli of insects, appear to be capable, judging by the actions of the creatures, of seeing things very distinctly.

Insects which live in darkened places, or in the ground, or are nocturnal in their habits, have usually small eyes, and long antennæ or feelers, while those which prefer daylight generally have large eyes and shorter antennæ.

It has been surmised that possibly the eyes of insects magnify objects, and that they obtain pleasure in viewing the beautiful forms of their eggs; but since there are many things in nature the beauty of which can only be seen by mankind, and often then only with the help of the microscope, this does not appear to be a good argument in favor of the magnifying power of insects' eyes.

In most insects the eyes are sessile or fixed; but in some they are borne upon stalks or pedicles, which are immovable; such is the case in the globular compound eyes of the beetle Stylops. In most crustaceans, such as shrimps, crabs, and lobsters, the two compound eyes are situated at the extremities of movable pedicles or peduncles; these creatures are therefore said to be podophthalmate, or foot-eyed.

The transparent tough skin forming the cornea of each compound eye in crustaceans is divided into a large number of small square facets, each forming a separate eye. In the common, edible crab (Cancer pagurus), the lobster (Astacus gammarus), and in the shrimp (Crangon vulgaris), there are 10 facets per 1-64 inch, the sides of each square being 1-640 inch long. In the Norwegian lobster, or "Dublin prawn" (Nephrops norwegicus), there are 6 facets per 1-64 inch, the sides being 1-384 inch long. In the case of the crab there are about 4,000 facets, in the lobster 16,600, in the hemispherical eyes of the shrimp 4,200, and in the Norwegian lobster 17,500 facets in each eye.

The facets in the eyes of the Paguoridea, such as the hermit crab (Eupagurus bernhardus), and also in those of the Squillidae, or mantis shrimps, which grow to a length of about 8 inches in Tropical seas, are regular hexagons in shape. In the crab named Podophthalmus, the eyes are borne on long stalks, as are also those of another crab called Macrophthalmus pectinipes, from the Persian Gulf. The gigantic crab Paranola cuvieri has flexible chitinous eye-stalks 1 inch long; but the large hermit crab, Pagurus punctulatus, from the Indo-Pacific seas, has a hard, calcareous covering to the eye-stalks. The earliest known creatures that possessed a pair of compound eyes are the fossil Trilobites of the Cambrian, Ordovician, and Silurian epochs, the rocks of these periods being the lowest in which animal remains have been found. Trilobites were marine crustaceans of all sizes up to about 2 feet in length, and resembled woodlice in outward appearance; they had two pairs of short legs under each segment of the body, and could roll themselves into a globular form like the pill woodlouse (Armadillidium vulgare), their eyes were crescent-shaped, and were placed either close together on top of the cephalothorax, or wide apart, one at each margin of the head. In the large Trilobite named Asaphus isotelus, from the Lower Silurian, each eye measures 1¾ inch by ½ inch, and the facets, as in the case of the woodlouse, are circular in shape. In some Trilobites, each eye has from 80 to 90 rows of facets, with about 20 facets in each row, or a total of from 1,600 to 1,800; but in the genus Caphyra there are as many as 15,000 facets in each eye.

The existing king or horseshoe crabs of the order Xiphosura, and named Limulus polyphemus, Xiphosura polyphemus, and Carcinoscorpius rotundicauda, among several others now found in Tropical seas, are the sole remaining representatives of the ancient Trilobita, which with the Merostomata (lobster-like crustaceans) are now extinct. The king crabs have four eyes—namely, two lateral compound eyes, and two small ocelli or simple eyes, situated closely together on top of the cephalothorax, or carapace, with the exception of the horseshoe crab (Tachypleus gigas) in which the ocelli appear to have become atrophied. The large fossil king crab Limulus gigantea, found in the Solenhofen stone, Upper Oolite of Bavaria, had four eyes, as had also the small species Euproöps rotundata, from the Upper Carboniferous coal measure. A fossil relative of the king crabs, and named Neolimulus falcatus, which was found in Oolitic rocks, had four simple eyes in a row, on top of the cephalothorax, in addition to the two compound eyes on the lateral margin. Belinurus, from the Carboniferous formation; Protolimulus from the Devonian; and Hemiaspis, from the Silurian, were crustaceans allied to the king crabs, and they possessed compound eyes.

Some other Upper Silurian crustaceans that somewhat resembled lobsters, and which grew up to 2 feet or 3 feet in length, have been named Pterygotus osiliensis, Hughmilleria socialis, and Slimonia acuminata; they had two fixed lateral compound eyes, and also two small ocelli or median eyes, on top of their heads.

The fossil skulls of the extinct salamander-like amphibians named Protriton, Pelosaurus, and Branchiosaurus, from the Triassic rocks, have a circular opening in the parietal bone on the top of the skull for a third eye, known as the "pineal eye," a similar hole also exists in the skulls of the extinct crocodile-like reptiles or Labyrinthodonts, called Mastodonsaurus, Metoposaurus, Archegosaurus, Trematosaurus, and Loxomma, from the Upper Triassic formations; in fact, Trematosaurus (hole lizard) has been so named because of the large size of the foramen for the pineal eye; the extinct reptile Diadectes found in the Permian formation had also a large median eye; while Pariasaurus baini, which was a large Anomodont reptile that was discovered in the Triassic rocks of South Africa, had probably a median eye beneath the skin, ¾ inch in diameter.

It is probable that some of the remote salamander-like ancestors of these animals had a useful median eye on top of the head in addition to the two ordinary lateral eyes, for the third eye seems to be very persistent; in fact, the Tuatera lizard (Hatteria punctata) of New Zealand, which is one of the sole surviving representatives of the ancient extinct reptiles, has a pineal eye and gland sunk between the lobes of the brain, underneath a small hole in the roof of the skull, which is covered by skin. The pineal gland is found in the heads of most vertebrate animals, including man. Some larval forms of salaman-

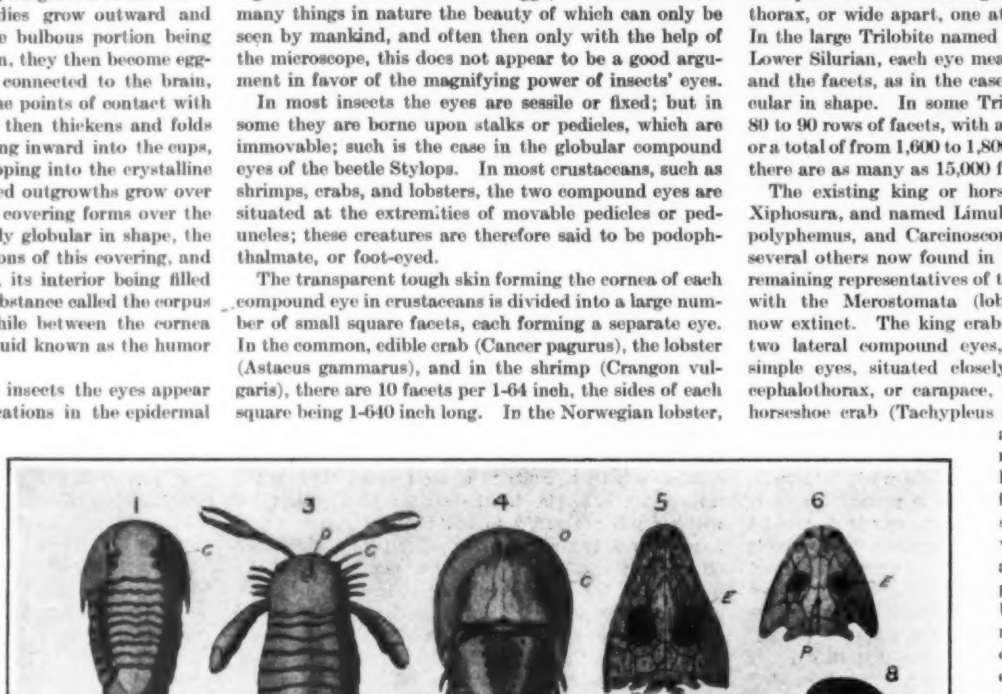

Fig. 1—Trilobite (Asaphus megistos). Fig. 2.—Eye of trilobite. Fig. 3.—Pterygotus osiliensis. Fig. 4.—King crab (Ziphosura polyphemus). Fig. 5.—Skull of Mastodonsaurus giganteus. Fig. 6.—Skull of extinct salamander, Pelosaurus, Fig. 7.—Skull of Pariasaurus baini. Fig. 8.—Eye of "Dublin prawn," or Norwegian lobster (Nephrops norwegicus). Fig. 9.—Facets of eyes of Norwegian lobster. Fig. 10.—Section of eye of Norwegian lobster showing facets F, cones C, and pigment spaces P. Fig. 11.—Eye of Tropical crab (Paromola cuvieri). Fig. 12.—Eye of prawn (Leander serratus). Fig. 13.—Eye of common shrimp (Crangon vulgaris). Fig. 14.—Eye of edible crab (Cancer pagurus). Fig. 15.—Eye of hermit crab (Eupagurus bernhardus). Fig. 16.—Facets of eyes of hermit crab. Fig. 17.—Part section of a compound eye, showing facets F, cones C, pigment P, nerves N, nerve ganglion G, and optic nerve O. Fig. 18.—Deep sea fish (Gastrostomus bairdi), showing phosphorescent eye-spots at S. Fig. 19.—Eye of scallop (Pecten). In the figures E = simple eyes, P = Parietal eyes, C = Compound eyes, and O = ocelli.

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der have functionless eyes, while the Texas subterranean salamander Typlomolge rathbuni has two eyes under the skin of its head; but it is quite blind. So also is the Olm (Proteus anguineas), which is found in the underground waters of the caves of Carniola, Dalmatia, and Carinthia.

In the Asteroidea, or star-fishes, there is a single tentacle at the end of each arm, which is known as the unpaired tentacle, and above this there is a red eye-spot. In the common star-fish Asteracanthion rubens, which has five arms, there are, therefore, five ocelli, or simple eyes. Some of the sea urchins (Echinoidea) possess eyes. In the scallop or Pecten there are from 40 to 46 transparent or purple eye-spots ¼ inch to 3/8 inch apart along the under side of the edge of the mantle in the lower, or flat shell, and from 14 to 17 in a similar position in the continuation of the mantle in the upper or curved shell, in which they are spaced about ¼ inch apart. They are situated among the numerous shorter tentacle-like filaments, and are glistening hemispherical bodies 1/50 inch to 1/32 inch in diameter.

In the accompanying table the approximate sizes and the number of facets in the compound eyes are given.

Some species of the Chiton, or mail shell mollusca (Chitonidæ), have about 10,000 eyes on the exposed dorsal surfaces of their shells, and the Annelid, or red-blooded worm Polyophthalmus (many-eyed), has a pair of eyes on each segment or somite of its body, in addition to the two on its head; some marine worms have eyes on the last segment of their bodies, while others have them on their tentacles and gills. The two head-plumes, or branched tentacles of the marine tube worm Serpula are covered with numerous eyes.

In the freshwater leech (Hirudo medicinalis) there are ten black eyes on the top of its head; but in the ordinary landworm (Lumbricus) eyes are absent. Some of the marine snails have two eyes at the base of the tentacles on the head. This is also the case with freshwater snails (Bithynia tentaculata), while land snails and slugs have an eye at the end of each of the two longest tentacles, or so called "horns."

The eyes of fishes either increase in size, or degenerate, with the increasing depths of water they inhabit, and some fishes and crustaceans that live in caves, or in muddy waters, are quite blind.

The rays of the sun do not apparently penetrate the sea to such a depth as to have any effect upon a photographic plate 1,300 feet below the surface, although it is probable that there is a slight greenish light at greater depths; but in the profoundest depths there is probably a dense darkness, which is only lit up by the phosphorescent lights emitted by many of the starfish, crustaceans, and fishes which inhabit some of the deepest portions of the great oceans. Bathynomus giganteus is a deep-sea crustacean 9 inches in length, and resembles a gigantic Isopod or woodlouse; it has been found at a depth of 3,400 feet, and has two compound eyes, each of which contains about 4,000 facets; while Anuropus, another deep-sea Isopod, has also compound eyes.

A small species of deep-sea shrimp, named Nematoscelis microps, has seven luminous red spots on each side of its body, in addition to the normal eyes; the spots are at the base of each somite or joint, close to the legs, and are believed to be accessory eyes.

Most of the deep-sea stalk-eyed crustaceans or Thoracostraca, such as crabs, lobsters, and shrimps, are totally blind, while about 66 per cent of the fishes are quite blind, and 34 per cent have large eyes; some of these, such as Gastrostomus bairdi, from a depth of 13,200 feet, and Chauliodus sloani, dredged from 15,000 feet depth, have a row of white phosphorescent spots on each side of their bodies, extending from the head to the tail; while others have only a few spots on the head. These spots are luminous organs, and are closely allied in their structure to a visual eye.

Some of the oldest known forms of fossil fishes found in rocks of Devonian age, and named Pterichthys, or wing fish, had their bodies covered with calcareous plates of armor and were provided with a pair of compound eyes; while both Pterichthys and Pteraspis had a plate between the eyes, with a hole in it for a median eye.

Crustaceans.	Number of facets per 1/64 inch.	Diameter of facets (inch).	Number of facets in each eye.
Crab (small), Cancer pagurus	10	1/640	4,000
Shrimp, Crangon vulgaris	10	1/640	4,200
Prawn, Leander serratus	7	1/448	3,200
Lobster, Astacus gammarus	8	1/512	16,600
Norwegian lobster, Nephrops norwegicus	6	1/384	17,500
Insects.			
Small white butterfly, Pieris rapæ	20	1/1280	9,300
Wasp, Vespa vulgaris	18	1/1152	5,500
Drone fly, Eristalis tenax	16	1/1024	14,500
Blow fly, Calliphora erythrocephala	13	1/832	5,300
Poplar hawk moth, Smerinthus populi	15	1/960	9,400
Hive bee, Apis mellifica	18	1/1152	7,900
Grey flesh fly, Sarcophaga carnaria	18	1/1152	3,800
Humble bee, Bombus terrestris	13	1/832	5,600
Stag beetle, Lucanus cervus	15	1/960	11,300
Carabus beetle, Carabus hortensis	18	1/1152	7,600
Lace-wing fly, Chrysopa vulgaris	22	1/1408	1,300
Crane fly, Tipula oleracea	18	1/1152	3,400
House fly, Musca domestica	22	1/1408	5,700
Cockroach, Blatta orientalis	16	1/1024	2,300
Lime hawk moth, Smerinthus tiliæ	16	1/1024	5,900
Silver washed fritillary butterfly, Argynnis paphia	16	1/1024	7,700
Horse fly, Tabanus bovinus	12	1/768	7,200
Pale tussock moth, Orgyia pudibunda	16	1/1024	6,000
Great dragon fly, Libellula pratensis	11	1/704	27,800

Fig. 1.—Head of drone-fly (Eristalis tenax). Fig. 2.—Head of great dragon-fly (Libellula depressa). Fig. 3.—Head of peppered moth (Amphydasis betularia). Fig. 4.—Facets of eyes of peppered moth. Fig. 5.—Head of small white butterfly (Pieris rapæ). Fig. 6.—Head of house-fly (Musca domestica). Fig. 7.—Facets of eyes of house-fly. Fig. 8.—Head of ant (Formica niger). Fig. 9.—Head of larva of scarce vapourer-moth (Orgyia gonostigma); Fig. 9a.—Ocelli of scarce vapourer-moth larva. Fig. 10.—Head of wasp (Vespa vulgaris). Fig. 11.—Facets of eyes of wasp. Fig. 12.—Head of larva of wood tiger-moth (Parasemia plantaginis). Fig. 13.—Head of humble bee (Bombus terrestris). Fig. 14.—Head of carabus beetle (Carabus hortensis). Fig. 15.—Head of lace-wing fly (Chrysopa vulgaris). Fig. 15a.—Facets of eyes of lace-wing fly. Fig. 16.—Facets of eyes of Red Admiral butterfly (Pyrameis atalanta). Fig. 17.—Head of blow-fly (Calliphora erythrocephala). Fig. 18.—Head of horse-fly (Tabanus lineola). Fig. 18a.—Facets of eyes of horse-fly. Fig. 19.—Head of false spider (Datames girardi). Fig. 20.—Head of house spider (Tegenaria domestica). Fig. 21.—Head of woodlouse (Oniscus asellus). Fig. 21a.—Facets of eyes of woodlouse. Fig. 22.—Head of jumping spider (Epibleum scenicum). Fig. 23.—Head of scorpion (Pandinus imperator); in the scorpion Opisthophthalmus austerus the ocelli are placed at *E* in lieu of the position shown at *O*. In each case O = Ocelli or simple eyes, and C = Compound eyes.

In the development of the Crustacea from the egg there are four stages: first, the Nauplius, which has a single eye; secondly, the Zoae or Copepod stage, in which there are two compound eyes; thirdly, the Schizopod stage; and, lastly, the adult, both with compound eyes. The shrimp named Penœus passes through all these stages, but in many crustaceans the Nauplius stage does not take place; the crab begins with the Zoae form and the lobster with the Schizopod.

Barnacles (Lepas anatifera) and Acorn shells (Ballanus porcatus) begin life in the free-swimming Nauplius form, with a single eye, they then change into the Zoae stage with two eyes, and resemble Daphnia, the microscopic fresh-water crustacean.

The eyes of the nautilus (Argonauta argo) are of a very simple type; they are about ½ inch in diameter and are shaped like a basin, with a flat membrane stretched over the top; in the center of this membrane there is a small pinhole, through which the water enters and fills the eye; it is, in fact, a pinhole camera, there being no lens or cornea proper; the light passes through the pinhole and through the water, on to the retina connected with the optic nerve.

The large eyes of the squid, cuttle-fish, and other Cephalopod mollusca, which contain lenses, pass through similar stages when in the embryonic condition to those of the nautilus.

The shell-less Gastropod mollusc named Peronia tongana, of the family Onchidiidæ, which is found on the coasts of the Pacific Ocean, has about 98 eyes of the vertebrate type arranged along its back, in addition to the two eyes at the ends of the tentacles on its head, which are of the invertebrate form.

In insects the head and thorax are separate, but in the Arachnida, or spiders and scorpions, the head is joined to the thorax, being known as the cephalo-thorax or carapace.

In spiders the eyes are situated at the head end of the cephalo-thorax, but in some scorpions there are eyes at the back as well as in front of the cephalo-thorax.

Spiders have either two, four, six, or eight simple eyes or ocelli, according to the species, on the top or front of the head, varying from 1/200 inches to 1/400 inch in diameter; but most species have eight eyes, the two largest ones being near the top of the head, with two smaller ones above them, and two on either side, placed closely together; these little eyes sparkle like drops of quicksilver when the spider is alive.

In the mygales or bird-eating spiders (Mygalomorphæ and Aviculariidæ) the eight eyes are raised on a little mound, called the "ocular tubercle," on the front of the cephalo-thorax. While the Solifugæ, which are large active false spiders with chelices or pincers somewhat similar to those of a scorpion, and which inhabit the forests and deserts of Africa, Asia, and the warmer parts of North and South America, feeding on insects, have only two ocelli placed closely together on the front of the head, and two tubercles, one on each side of the head, each of which bears an obsolete eye. The tarantula spider (Tarantula carolinensis) has two large ocelli near the top of the head and four eyes in a row below.

Scorpions have eight ocelli, three small ones are situated in a row on each side of the front of the cephalo-thorax, and two large median eyes are placed close together on top of the head, about half way along its length; but in a certain South African genus, Opisthophthalmus austerus, the two median eyes are situated close to the back of the cephalo-thorax. The eyes of scorpions are not supposed to be very efficient, as the creatures are nocturnal in their habits.

Woodlice, which are terrestrial crustaceans, have two crescent-shaped compound eyes, one on each side of the head; the common smooth woodlouse (Oniscus asellus), the rough woodlouse (Porcellio scaber), and the black pill woodlouse (Armadillidium vulgare), which latter can roll itself into a ball shape, have each four rows of about eight facets, amounting to thirty-two in each eye; these facets are circular and resemble ocelli placed closely together, but not so as to touch one another.

The common yellow centipede (Lithobius forficatus) has also two compound eyes with circular facets, consisting of four rows of six ocelli, or twenty-four in each eye; these facets are spaced farther apart than in the case of the woodlouse. The black cylindrical millipede (Julus sabulosus) possesses two compound eyes behind the antennæ, each consisting of five rows of ocelli separated from one another, and totaling about forty to each eye. The giant centipede (Scolopendra gigas) has also two lateral compound eyes.

The hexagonal facets of the compound eyes of insects are generally about 1/768 inch to 1/1,280 inch in diam-

eter, irrespective of the size of the insect or its eyes, there being usually twelve to twenty facets per 1/64 inch, the surfaces of which are slightly dome-shaped. The ocelli, when present, are generally larger, varying from 1/100 inch to 1/500 inch in diameter, and are usually three in number, being situated on top of the head on the median line, two ocelli being above and one ocellus or stemma below in triangular form. Most of the Diptera, or two-winged flies, and the Hymenoptera, or membrane-winged insects, have three simple eyes, in addition to the two compound eyes. In the earwig (Forficula auricularia), there are two compound eyes, each having about 1,200 hexagonal facets, which are each about 1/1,000 inch in diameter. The chitinous skin on the head is covered with roughly hexagonal divisions, each about 1/2,500 inch in diameter, which indicate the origin of the eye facets. The cockroach (Blatta orientalis) has in addition to its compound eyes two yellow simple eye-spots behind the antennæ.

Locusts and grasshoppers have three ocelli in addition to the lateral compound eyes—one is situated in front of the head and two behind the antennæ; but the young locust is destitute of compound eyes, having instead groups of ocelli, which during the growth of the insect, increase in number and finally form the compound eyes. The aquatic larvæ of dragon-flies, May-flies, and water-beetles possess compound eyes; but the larvæ of land beetles (Coleoptera), especially those that live underground, are often eyeless. The caterpillars of most moths and butterflies (Lepidoptera) have a number of simple eyes on each side of the head close behind the antennæ, and near the jaws, they usually number from three to five on each side, and are arranged in a semicircle.

The larva of the American butterfly (Danais archippus) has three simple eyes on each side of the head, while the caterpillar of the boat-moth (Hypoptà cossus), which lives in old tree-trunks, feeding on the rotten wood, has apparently no eyes; this is also the case with many others that live in dark places.

The membrane covering the heads of caterpillars being transparent, it is probable that the brain is sensitive to light, and that even those larvæ which are eyeless can distinguish between light and darkness. The beautiful caterpillar of the scarce vapourer-moth (Orgyia gonostigma) possesses two large ocelli and three small ones on each side of its head, and, in addition, about fifteen minute ones on either side, arranged round the larger simple eyes; but the number of these small eyes is variable.

The larva of the wood tiger-moth (Parasemia plantaginis) has five ocelli on each side of its head, so also has that of the cinnabar-moth (Hipocrita jacobaeæ); but the grub of the American oil, or blister beetle (Epicauta vittata), has two compound eyes. The green larva of the small white butterfly (Pieris rapæ) has three black ocelli, and three transparent ones on each side of the head behind the antennæ. The larvæ of the oil-beetle (Meloidæ) are peculiar for undergoing three distinct larval forms, or hypermetamorphoses; they are parasitic in the nests of bees, and have two compound eyes; while the larva of the parasitic fly Ophion lutus, that lives on the caterpillar of the puss moth (Harpyia vinula) has two compound and three simple eyes.

The great dragon-fly (Libellula pratensis) has very large compound eyes, each containing about 27,800 hexagonal facets, and has two stemmata about 1/100 inch in diameter, while the ichneumon-fly (Ichneumon persuasorius) has three remarkably large oval ocelli, each about 1/50 inch in diameter, in addition to two compound eyes with hexagonal facets. The Agrionidæ, or slender-bodied dragon-flies or demoiselles, have three ocelli in addition to the compound eyes. In the leaf-hopper (Erythroneura vitis) there are two compound and two simple eyes; the skin near the eyes is corrugated and gradually merges into hexagonal colorless facets, which become filled with pigment, and are colored in the eye proper. The water-measurers (Gerris paludum) have two beautiful hemispherical compound eyes, each 1/100 inch in diameter, with hexagonal facets having curved surfaces, and short hairs at the angles of the facets; there is also one large simple eye, and above this there are two tubercles, which appear to be atrophied eyes.

The eyes of the blow-fly or bluebottle (Calliphora erythrocephala) have beautiful brown hexagonal facets, and there are three simple eyes, each about 1/400 inch in diameter; while the house-fly (Musica domestica) has also three ocelli, each about 1/500 inch in diameter, and there are hairs between the facets of the compound eyes. In the grey flesh-fly (Sarcophaga carnaria) the facets of the compound eyes are not always very regular in form; some have two short sides and four long ones, and *vice versa;* there are three large ocelli, each about 1/150 inch in diameter.

The large eyes of the drone fly (Eristalis tenax) have hairs between the hexagonal facets, and there are three ocelli; in fact, a large number of genera and species of flies have three simple eyes in addition to the compound ones, but the horse-fly (Tabanus lineola) has only two ocelli. The common wasp (Vespa vulgaris) has two curiously shaped compound eyes, and three ocelli on top of the head each about 1/150 inch in diameter; the facets of the large eyes are six-sided, but they appear to be almost square, as two sides are very short. The humble-bee (Bombus terrestris) has beautiful hexagonal facets in its elongated compound eyes, and there are three stemmata, while in the case of the hive-bee (Apis mellifica) there are two compound eyes with long hairs between the facets, and three simple eyes on the top of the head, each about 1/300 inch in diameter; they are arranged in the form of a triangle, the base of which is uppermost.

The male and female winged ants (Formica) have three ocelli in addition to the compound eyes, which are 1/100 inch in diameter, and each contain about fifty facets, but the workers or soldiers have no simple eyes. The book-lice (Psocidæ) have two compound eyes and three ocelli, but bird-lice (Mallophaga) have only simple eyes; in some of the springtails (Collembola) the eyes are formed of separate or grouped ocelli. In the cicadas (Cicadidæ) there are three simple eyes, and in the lantern-flies (Fulgoridæ) there are two in addition to the compound eyes.

The crane-fly, or daddy-long-legs (Tipula oleracea) has very regular hexagonal facets in its hemispherical eyes, so also has the lace-wing fly (Chrysopa vulgaris). The facets in the eyes of the latter are separated by wide septa which contain a green fluid; it is this fluid that reflects the beautiful golden color which is peculiar to the eyes of this insect; the eyes are each about 1/50 inch in diameter, and at each angle of the facets there is a short spine or hair.

Butterflies and moths (Lepidoptera) have all got beautiful compound eyes with hexagonal facets; the former have no ocelli, but the latter have two; these are placed behind the bases of the antennæ and on the borders of the compound eyes. In the case of the Red Admiral butterfly (Pyrameis atalanta) there are remarkably long hairs projecting from the corners of the facets, which would probably veil to a certain extent their sense of sight. Beetles (Coleoptera) have, as a rule, no simple eyes, but have small compound ones with regular hexagonal facets; some of the rove beetles (Staphylinus) possess ocelli in addition to the compound eyes; there are two in the genus Homalium, and a single stemma in Phlœobium.

Engineering in the Navy

By W. L. R. Emmet, Consulting Engineer, General Electric Co.

WHILE the navy has accomplished much in the direction of constructive engineering, most engineers and manufacturers who have been connected with naval work have felt that they labored under great difficulties and have desired some change of practice or organization which might render such efforts more effective.

New developments in engineering generally entail much labor and expense, even where the objects are very simple. There is scope for much thought in every construction if it is to be brought to a state of ideal fitness, and much experience has shown that new things do not pay unless they are done with great care and thoroughness.

The navy is in constant need of inventive development and much of its need relates to things which have no appropriate application outside of the navy itself. Improvements for the navy must come from within or from outside sources. If they are to come from within the navy itself means must be provided for the necessary expenditure of time, study, experimentation, and construction, and if they are to come from outside, incentives must be afforded to those who have the facilities for doing such work. It would seem that the present conditions do not fully meet either of these requirements. Some conditions may be suggested as possible reasons for these difficulties.

The first of these is the lack of authority and scope for continued effort afforded to engineers in the navy. Few officers other than the naval constructors are permanently engaged in engineering work and few are so detailed as to be able to devote themselves to one thing long enough to establish the influence and grasp of conditions necessary in the putting through of difficult undertakings. Executive and financial men in or out of the navy can seldom form sound judgment about engineering matters, particularly new ones, and engineers must be trusted and given ample authority in connection with such undertakings if the best progress is to be expected. In private industries, certain well-tried men are so trusted after experience has shown that their judgment is dependable. The navy system does not tend to sufficiently establish the influence of such men. There are many bright men, but it would seem that they lack scope for effective continuous effort.

Another difficulty is that the law and the yearly acts of Congress only allow certain specific expenditures, and it is hard to get money from Congress for activities which cannot be made to appear attractive to laymen in a paragraph of an appropriation bill. The navy should be organized to do research and development work as great corporations do it, funds should be provided for it, and at least a few men of the highest type should be kept on it without frequent and unnecessary changes of duty.

If the navy desires to render the study of its problems attractive to private manufacturers, it must modify the system of price competition upon which it now operates and must do as great private purchasers of machinery do, it must have expert men in positions of influence and authority who can be trusted to purchase for reasons other than price, and whose positions are such that their good faith can be depended upon not only by the government but by those who do work for the navy. The great difference which generally distinguishes private business from public is that the former is largely governed and expedited by individual trust and judgment of character, while the latter is governed mainly by law and formula; but while this limitation of government business is common it is not invariable and there seems to be no good reason why the navy should not be, to a great extent, relieved from a condition which interferes so seriously with constructive activities in engineering lines.

It would be interesting to know whether such men, for example, as Sir William White have not enjoyed in foreign navies a scope and permanence of engineering authority which is superior to that afforded to the many fine engineers who have served our navy.

It would seem that the accomplishment of such objects as are here suggested would necessitate some change in the organization of the personnel of the navy or in the customs governing its use. In the opinion of the writer, the present practice of using experienced seagoing officers for much of the important engineering work of the navy is a very good one, which should be continued. It is believed that every department of technical work in the navy, including that of construction and repair, will be benefited by the services of such men. It is believed, however, that the activities of these men should be supplemented by a moderate number of first-class experts, who, as a permanent engineering corps, can devote their lives to the practice of engineering. Such a corps should not be recruited from newly graduated cadets. It has been often proved that success as a student affords little indication of value as an engineer. Its members had better be taken from experienced officers and civilian employees of the navy who have reached the age of thirty and have shown the ability and character necessary to usefulness in such work. The members of this corps should hold positions of influence and importance in departments of the navy where engineering work is done. Their activities should generally be of a purely engineering rather than of an executive character, although they should not be entirely excluded from executive positions.

The possibility of making improvements in the equipment of existing vessels in the navy affords a very ready and practical means of making experimental development of new methods and devices, but such changes if they involve much expense can generally not be undertaken without authority from Congress. It may be quite as desirable to bring an old ship up to a higher standard of efficiency as it is to improve the design of a new ship, but under existing conditions it would seem that new methods must generally await their opportunity until new ships are authorized. In the opinion of the writer it would be desirable to provide an ample fund which could be used at the discretion of the Secretary of the Navy in developmental work, either through purchase of machinery or through manufacturing and experimenting in navy yards. Where these developments resulted in permanent improvements to vessels, the fund could be duly credited.—*The General Electric Review.*

Superficial Deformation of Steel on Quenching

EXPERIMENTS by B. Bogitch, as reported in *Comptes Rendus*, confirm previous observations made by Zschokke on the appearance of undulations on the surface of pieces of polished steel when quenched from temperatures between 225 deg. and 400 deg. Cent. The undulations first made their appearance on quenching from temperatures in the neighborhood of 215 deg. to 220 deg. Cent.; they increased in width as the temperature rose, and disappeared completely when the temperature of quenching was above 360 deg. It was found that as the temperature of quenching water rises, the temperature interval in which undulations can be obtained is diminished; in fact no markings were obtained on samples quenched in boiling water. The duration of heating is of considerable importance in determining the structure obtained at any temperature, as also is the size of the sample. Samples less than one centimeter square gave no surface marking on quenching. After once quenching the sample was found to have lost its property of producing undulations, and the property could only be restored by annealing from temperatures above 700 deg. Cent.

The Paper Textile Industry*

Many Products in Which Paper May Be Substituted for Other Fibers

In recent years the manufacture of paper textiles has made a notable advance. The idea is not new. From time immemorial the Chinese and Japanese have employed paper in forming rope with which to tie bales and packages, and as fine yarn, used for weaving purposes. Even to-day in Hongkong it is not unusual for a Chinese merchant to twist a strip of paper to tie a bundle for his Celestial customer.

In the United States after the Civil War, during the memorable cotton famine period, more or less successful attempts were made to produce paper twines, but this industry was gradually eliminated with the return of a normal supply of cotton, and with the exception of one mill, all these early attempts were abandoned. There is one successful mill in the South to-day which dates its beginning from this period.

Experiments with paper textiles have never ceased, especially in England, Sweden and Germany. In 1892 two German engineers, Keller and Turk, produced the first truly commercial paper twisting machine, which was soon followed by another type by Claviez in 1897, and shortly after two other Germans, Muller and Kron, brought out still another twister. With these machines it was possible to develop the field on a commercial basis and insure its permanency.

MACHINERY NO LONGER A NOVELTY.

The paper twister to-day is no longer a novelty. There are at least a dozen different machines on the market, and two of them are of American make. The industry has grown steadily and in several countries has gained quite a notable success in various articles. Japan employs paper to a considerable extent as a filling in silk ribbons. England excels in heavy ropes and twines with other fibers as the core. Germany has developed the bag and wrapping industry and at present, when jute is unobtainable, the paper yarn manufacturer is "the man of the hour," producing not only a substantial, but a cheap substitute.

In the United States an excellent line of floor coverings is being manufactured. There are a number of successful mills whose yearly output in all paper and wool floor coverings runs into the millions, and recently earnest attempts have been made to use this material for baggings and other articles where until now only jute has been used.

MANUFACTURING PROCESSES.

The manufacturing process of paper yarns is similar on all types of machines; the raw material, paper, is cut into narrow strips varying from one eighth of an inch to four or even five inches in width. In European countries, only the very best Swedish kraft is used, which has a strength that rivals other textile materials. Such stock is used in two of the American paper yarn mills. One Southern mill uses an American made sulphite sheet for the heavier yarns, and light-weight tissue paper for the finer numbers. Two large carpet mills in Massachusetts and Pennsylvania use tissue paper almost entirely, while another mill in the Middle West has succeeded in making a satisfactory yarn from a very cheap paper stock, the twisting of which up to this time has been considered an impossibility.

Paper twisting may be divided into two operations. First, the preparation of the stock; second, the actual twisting. The first process consists in slitting the big paper rolls, which weigh from three to seven hundred pounds, into narrow strips of various widths and rewinding them into solid disks, ready for the paper twister. This process, while on the surface a simple one, corresponds with the carding preparation of other textile materials. It requires the utmost care and attention because the amount of waste made in the twisting and the quality of yarn depends upon how carefully this process has been performed. The disks must be wound tight and straight so as to separate from each other easily. There are a number of slitters made in the United States, one of them being especially suitable for this industry.

TYPES OF TWISTERS.

Three types of twisters are used for the paper twisting industry. First, the disk system, which is the disinct feature of the Claviez process, where the disk coming from the slitting machine is put into flat holders, and the paper twisted by two small rolls placed above the disk and delivered to the spools. Second, the flyer system, which is used in most of the American and English machines. In detail construction these machines may vary. In some makes the legs of the machine are turned upward and the feeding takes place from the bottom; while in others the flyer is in the usual position and the feeding takes place from the top. The tension in most cases is obtained with a weight and band against the spindle or bobbin flange, and in some cases a spring is employed for this purpose. All heavy yarns must be twisted on the flyer system. For fine yarns the ring system has been perfected and gives very good results.

CONDENSATION AND TENSION.

The greatest problem confronting the constructor of paper twisting machines is not in the twisting operation itself but in the delivery, condensation and tension. Paper in the dry state, especially when cut into narrow strips, is an unelastic, harsh material. Commercial yarn cannot be made without proper tension, and this must be adjusted in proportion to the weight of the bobbin which, of course, increases in the process of filling up the spools. The next problem is the delivery of the paper strips to the twister without imparting too much tension, or too little. Since the process of drawing is eliminated, the paper strip goes direct to the delivery rolls, and to the guides of the twister, so there is still another factor of tension which requires consideration by the constructor.

If the tension on the spool is too great the yarn will break, and if not enough, the machine will produce an uneven, commerically valueless article. The tension must decrease in proportion to the size of the disk and the tension on the twister must increase in proportion to the diameter of the yarn thereon. As no machine has yet been built for such fine adjustment, a rigid overseeing is necessary. The paper strips are fed to most machines, flat, while on some they are condensed in a hollow tube turning the edges inward, thus reducing the possibilities of breakage.

DRY AND MOIST TWISTING.

Yarns made of tissue and other thin paper are twisted either day or moist, while heavy paper must be carried through a moistening device, softening the strip to make it more pliable for twisting. The Kron method differs from this procedure in that the cutting of the narrow strips is done right on the paper-making machine, thence carried into rubbing aprons similar to the ones used in wool carding, condensed into a round sliver, delivered in cans, kept in a moist condition, and taken to the twister.

Universally moistening is done in a copper tank filled with water, behind the feed rolls, to which various preparations of salts and gummy materials are sometimes added to increase the pliability and strength of the finished product.

COMPARISON WITH OTHER MATERIALS.

The greatest drawback in using paper yarn as a substitute for other materials is in its bulk, which often offsets the advantage of a lower price. The strength of paper yarn varies in proportion to the raw material and the twist imparted. The soft-twisted yarn made of tissue-paper cannot be compared in strength with jute or cotton yarns of the same bulk or diameter, while the hard-twisted Kraft or sulphite paper can successfully compete in strength with jute, but it is about twice as heavy, thus offsetting the advantage. The success and market value of paper yarns and twines lies not as a substitute for jute, cotton or other textiles, but in their adaptability in fields where the other fibers have shown undesirable features.

TWINES FOR TYING WOOL.

Paper twines for tying wool, instead of sisal or hemp, is an instance where success depends upon special fitness. Many hundred thousand pounds of paper twines are sold in a year for this purpose, and it will not be many years before they are universally adopted. Woolen manufacturers know that when a piece of sisal or jute is mixed in with the wool it will be carried through all operations with disastrous effect, while paper twine, if accidentally mixed in the wool, will dissolve during the scouring process and be thrown out during the carding.

There have been no serious attempts made to make wool bags of paper fiber which would have the same distinct advantage as the wool twine; but surely the future will bring a worth-while article for this purpose. Other fields where paper twines will be used successfully are the meat industry and tobacco packing. In spite of the fact that the industry is still in its infancy, quantities of paper yarn and rope are sold to the millinery and hat trade; for fuses in explosives, packing twines and reed substitutes. In the Middle West a large mill is making furniture, using paper fiber, with wire core, instead of reeds.

FUTURE OF AMERICAN YARNS.

The future of paper twines in the United States is in the coarse and medium size numbers, since the manufacturing of fine sizes has proved prohibitively high with our labor cost. Japan produces a paper yarn to-day that can hardly be distinguished from combed Sea Island cotton in strength and uniformity, made of bamboo paper, but it is higher in price than Sea Island cotton. There is a greater future in the American market for paper fabrics than for paper twines, as in the latter the field is limited to a few specialties, while in fabrics there is absolutely no limit.

FLOOR COVERINGS.

Fiber floor coverings manufacture, a truly American industry, is still in its infancy. There are no means of telling how it may develop. In the majority of paper floor coverings paper yarn is used as a filling with cotton or jute warp, in a half double fabric where one filling is a cheap shoddy, while the other is of a soft twisted tissue paper. Wonderful designs and effects can be obtained in these combinations, and a mill producing such articles was awarded a gold medal at the Panama Fair. Another method of using paper in floor coverings is with fine cotton warp, the filling is soft tissue paper beaten closely together. Such fabric in finer construction is also used for suit cases instead of Chinese matting. The objection to this kind of floor covering is that the warp wears out, and the soft paper filling consequently goes to pieces.

In the last few years an all-paper floor covering has been made by some mills where both warp and filling are paper and the designs are stenciled in oil colors similar to that of grass matting. Such all-paper floor coverings are usually made of Kraft paper, are hard twisted, waterproof and very substantial, but yet have a certain matting appearance which makes them rather a substitute for matting than an original article.

Recently a concern in the Middle West succeeded in producing a paper fiber carpet that has the softness and pliability of wool, elastic under foot, and a distinctly new departure from the usual article. The color effects are obtained by twisting the shades together on the four-ply basis, producing a soft mottled effect.

BAGGING AND BURLAP.

While our paper fabric industry can count to-day a half dozen mills producing floor covering exclusively, the bagging and burlap branch has fared with less success. It is very successful in Europe, but the high cost of manufacturing in the United States makes the competition difficult. This article was manufactured in New England but discontinued on account of lack of profits. On the other hand, another mill established about two years ago is fairly successful in producing specialties, notably bags for the shipment of vegetables, and there are indications that there will be a future development.

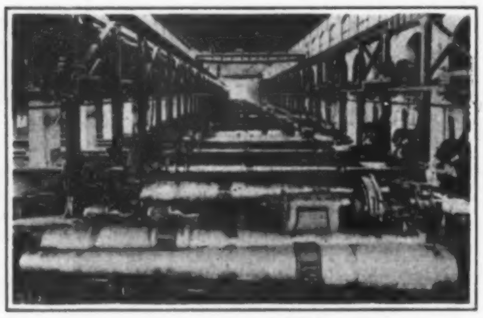
The possibilities of paper fabric for cotton bales were demonstrated last year by an actual test when cotton bales, covered with a heavy paper fabric, especially constructed for this purpose, were sent on a 3,000-mile trip, unloaded six times and arrived at the point of destination in excellent condition. The drawback in developing this field at present lies in the low price of gunny bagging. While all factors agree that the gunny sack is detrimental to the cotton, yet under present conditions the growers cannot be induced to adopt a superior wrapping at a higher price.

The tests conducted with cotton bales proved the surprising fact that the packing made of paper fiber is far less inflammable than jute, and being a smooth fiber, the cotton will not adhere to it, causing little waste at the opening of the bales. Paper fabric for cotton baling is a feature that will sooner or later come to the front.

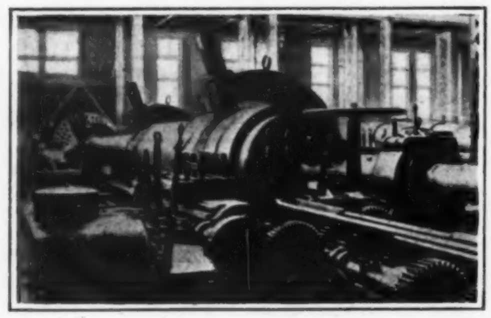
The articles that may be produced in woven fabrics are almost unlimited. While in the United States they are confined to floor coverings and a few specialties in baggings, Germany, England, Sweden and Japan have produced wall coverings, ribbons, quilting materials, towels with paper warp and linen or cotton filling, print cloth, especially for cretonne, upholstery goods with cotton warp and paper filling, horsehair cloth substitutes, carriage cloth, and many other articles, which have found their way to the market mostly in southern European countries.

An analysis of this industry in the United States proves that the paper textile industry has come to stay, but its success will be entirely in different lines than that of the European mills. The American consumer can at any time afford a cotton towel or a silk and cotton ribbon, and under normal conditions it will not be necessary to turn to paper. The future of the American paper textile industry lies in the creation of new articles, and the development of paper floor covering indicates that the American branch of the industry will lead the world in new fields instead of substitutions.

*By "Denina," in *Textile World Journal*.



In the gun shop of the Watervliet Arsenal.



Boring chamber of a 12-inch Navy gun at the Washington Navy Yard.

Chambering a 12-inch gun at the Watervliet Arsenal.

Large Naval and Coast Defense Guns

Their Process of Manufacture and Inspection

By G. H. Holden, Sub-Inspector Ordnance, U. S. N.

THE modern large gun has been developed to its high state of efficiency and simplicity of design within less than twenty-five years.

The success can be largely accredited to the valuable assistance rendered by the steel companies, who have developed in the art and production of steel. Wonderful strides have been the outcome of their endeavors, and hence our powerful weapons. The same also can be said of powder, projectiles and armor plate.

The manufacture of these heavy guns has become simplified through experience, and involves a heavy expenditure of money for equipment of open-hearth furnaces, forging presses and heavy rigid machinery; also it requires an efficient force of engineers to oversee the various processes.

The 12-inch or 14-inch B. L. rifle is made of eleven to fifteen component parts whose weight in the shape of cast ingots will be 1,000,000 pounds, and when machined and assembled into a finished gun weigh a little less than 130,000 pounds. To cast each of the six largest ingots, two open-hearth furnaces are required, and each charge is made up of 115 tons of material.

The tube or inner section is the first ingot poured, and it weighs 146,000 pounds. It is 63 inches diameter midway of its length with corrugations on its exterior surface. The mold tapers about 3 inches in its length and has a corrugated wall, which enables the mold to be easily stripped from the ingot when cold.

The steel for all gun forgings is made by the acid open-hearth process, and poured into an open mold from top or bottom. If the steel is to be fluid-compressed, it is poured from the top and the mold rests on a portable carriage, which, after the pouring, is moved under a hydraulic press. The upper piston is then lowered into contact with the hot fluid and locked. The pressure is then increased gradually from below by four pistons acting upon the table on which the mold rests until about 2,300 pounds per square inch is reached. This pressure is held until the metal has become solidified. The actual compression will amount to one eighth the original length of ingot.

When the ingot is stripped from the mold it is reheated for about fifty hours to a temperature of 2200 deg. F. in a gas heating furnace, and then placed under the press and rounded down. It is again reheated, reforged and drawn on the breech end of ingot for 30 feet. The muzzle end or top of ingot is then placed in the furnace, heated and forged and drawn out so that the finished tube is 63 feet long, 30 inches at the breech and about 18 inches at the muzzle.

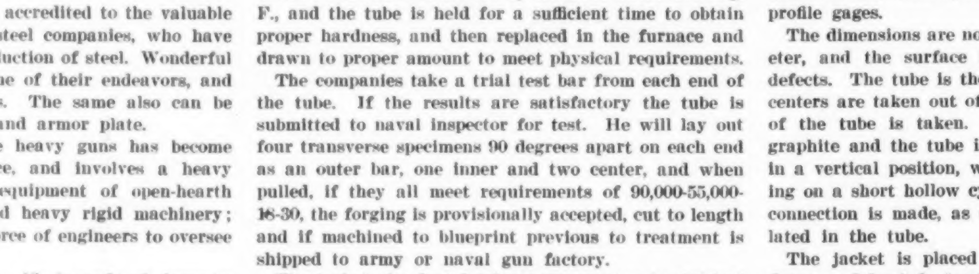
The forging is then given a high anneal to relieve forging strains, and when cool is machined to 0.5 inch of blueprint dimensions to develop any seams or defects. The tube now is sent to the boring shop and a 12-inch hole bored simultaneously from each end at a rate of 2½ inches per hour. This operation takes about 130 hours.

The forging is then heated in a vertical furnace 80 feet high for several hours to 75 deg. F. above the critical or *a c* 3 point and held a sufficient time, and is then removed from the furnace and lowered into a water tank 10 feet in diameter and 80 feet deep. The water in the tank is heated by steam to about 100 deg. F., and the tube is held for a sufficient time to obtain proper hardness, and then replaced in the furnace and drawn to proper amount to meet physical requirements.

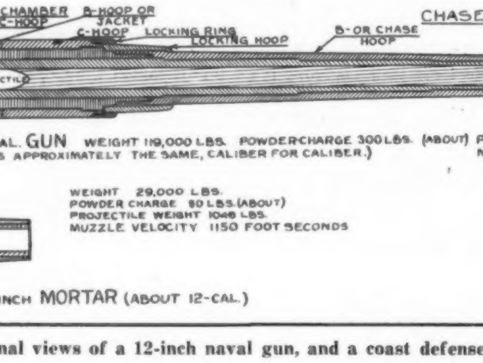
The companies take a trial test bar from each end of the tube. If the results are satisfactory the tube is submitted to naval inspector for test. He will lay out four transverse specimens 90 degrees apart on each end as an outer bar, one inner and two center, and when pulled, if they all meet requirements of 90,000-55,000-18-30, the forging is provisionally accepted, cut to length and if machined to blueprint previous to treatment is shipped to army or naval gun factory.

The jacket, the first forging component to be finished bored, is spotted on breech end for steady rest and secured in a chuck on muzzle end and is finished bored, which requires two or more cuts of .15 inch with packed bits, with feeds for the first cut ranging from 3.25 to 3.50 lineal inches per hour, or about 12 inches to 15 inches surface feet per minute.

In the final cut a feed of 4 inches to 5 inches per hour is attained. The jacket is faced square on breech end, the bore searched, as shown in the diagram, for sand splits or defects, and star-gaged for every inch of length of bore. The exterior is center punched every 24 inches of its length in a line parallel to its axis.



Sectional views of a 12-inch naval gun, and a coast defense mortar.



Search-light for detecting defects in bore of gun tubes.

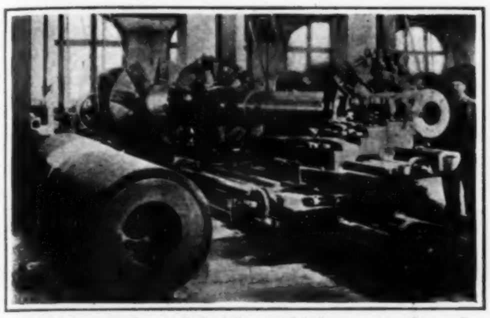
A sketch is now prepared, with dimensions as recorded in bore of jacket, plus a prescribed shrinkage, and given to mechanic to turn the exterior surface on breech end of the tube, which has also undergone a similar process of boring. The tube has been spotted by turning several spots throughout its length for steady rests, and is then preliminarily bored to within .25 inch of its finished size for a twofold purpose, first, to again bore-search for sand splits or other defects; second, to star-gage bore and record the dimensions.

The tube is replaced in the lathe and shrinkage dimensions are turned, and radius cut at shoulders to profile gages.

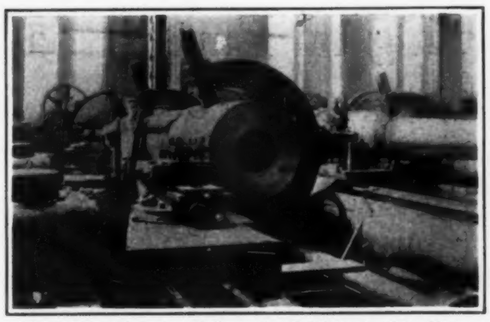
The dimensions are now checked for length and diameter, and the surface is closely scrutinized for any defects. The tube is then removed from the lathe, the centers are taken out of the ends, and the total length of the tube is taken. The surface is painted with graphite and the tube is then lowered into a deep pit in a vertical position, with the breech end down, resting on a short hollow cylinder, through which a water connection is made, as cold water is now to be circulated in the tube.

The jacket is placed in a vertical furnace, breech down, and heated about 30 hours with hot air to 700 deg. F. It is then removed from the furnace and gages are inserted in the bore to make sure proper expansion has been reached. It is brushed out and placed over the tube, and when properly centered with aid of wooden gages is lowered as quickly as possible until it brings up home on the shoulder. A coil of pipe is in position opposite this point, and a spray of water is applied to induce rapid cooling and diametric contraction, so as to insure as small an opening at the shoulder as possible and allow the jacket to contract uniformly throughout its length. When cold, the dimensions previously laid out are taken on the exterior and any extension is noted and recorded. The tube is again star-gaged and the amount of compression is recorded; also the total length is taken to note the amount of contraction due to shrinkage on jacket. This star-gaging must be done carefully, as operations which follow up to the final assembled gun will be a sequence of the same methods of inspection, and each foregoing one has to be verified and checked up by preceding results. When the gun is finally assembled it is placed in a lathe and rough machined on exterior surface to within a few hundredths of an inch, then removed and placed on the floor and star-gaged for its entire length at every inch and all changes recorded. Upon examination of the results we find that the difference between the dimensions of original bore, when all forgings are assembled, will amount to .025 at the breech and to about .015 smaller at the muzzle, and that the length of the tube will be found to be from .20 inch to .50 inch short, due to the stresses resulting from heating and contracting incident to the successive shrinkages. To secure as near true and accurate as possible results the gun is relieved of all excess of metal on exterior surface before this final star-gaging.

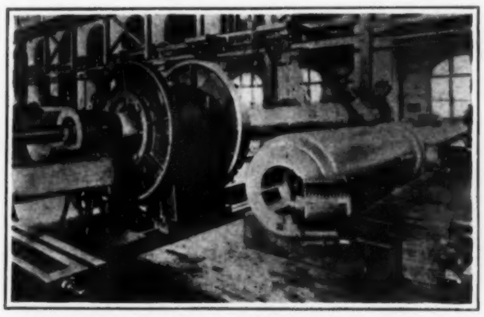
The gun is again placed in the lathe, the breech end secured in face-plate chuck, and finish-bored to 14 inches diameter. This operation is a particular one, as the tolerance is but plus .003 inch, and the gun having a length of 60-odd feet, it requires about two roughing and one final cut. The feed on these cuts will average six lineal inches per hour, or about 425 hours for this operation, packed bits being used. The gun is then reversed in the lathe and the muzzle end secured in the chuck. The powder chamber extends into the breech of



Facing muzzle and finish machining extension of 10-inch Army rifle at the Watervliet Arsenal.



Turning yokes to fit breech of 12-inch, 50-caliber naval gun at Washington Navy Yard.



10-inch gun in rifling machine, and rear view of finished gun on floor at Watervliet Arsenal.

gun for about eight feet, and that part of bore is now enlarged, and compression and bore slopes and gas check seats are cut. This requires about 350 hours.

The breech end is now bored and chased out and the screw-box liner is fitted. The exterior is now finish-turned, the tolerance being .01 inch except the slide and yoke fit, which have to be .003 inch plus.

The gun is again reversed and the bell muzzle is now finished. The gun is then placed on the floor and star-gaged for chamber and bore, and bore-searched for any defects throughout.

The next operation will be the rifling of the gun. The rifling bar has a primary groove cut spirally the entire length which acts to rotate a rifling head, which has three cutting tools or more, having a universal adjustment (as cutting tools are fed out after each cut). Besides the rotative motion the head also receives a movement of translation by being fed forward through a traverse feed screw. There are 84 lands and 84 grooves in a 14-inch gun, each having a depth of about 0.015 inch. This operation consumes about 150 hours.

The gun now is removed from the lathe, and the bore is lapped in a special machine carrying a plug fitted with longitudinal lead or copper strips. This plug, dusted with powdered emery, is pulled back and forth and removes the fins and burrs caused by the cutting tools of the rifling head. When this lapping is finished the bore is thoroughly swabbed out with burlap and benzine, and the interior receives its final bore-searching for torn lands or defects in grooves. The lands and grooves are now star-gaged and all changes recorded.

The breech mechanism will now be fitted to the gun, and the needed holes are drilled, bored and tapped into the breech, and the gas check seat is fitted and scraped to a gage. The name of manufacturer, the size, type or mark and modification of gun and mechanism, the year and inspector initials, and anchor or official mark are stamped on the breech face.

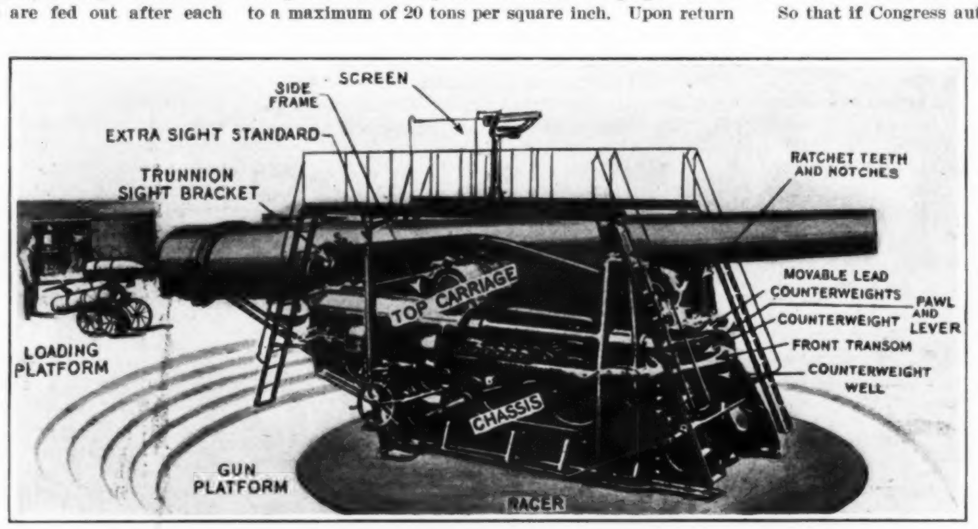
The gun now is shipped to the naval gun factory and fitted to its mount, and it is then sent to the naval proving grounds and subjected to a test ten rounds, the pressure in the powder chamber ranging from 10 to a maximum of 20 tons per square inch. Upon return to the gun factory the gun is cleaned throughout, bore-searched for defects, examined as to any readjustment of various forgings due to firing, and again is star-gaged. If satisfactory, the gun is paid for and assigned to a battleship.

There are at present but two steel companies equipped to forge these large forgings for 12-inch, 14-inch or 16-inch guns for army or navy, and their present combined capacity is but four sets of above forgings per month.

The average delivery for the two above companies for a finished gun built at the respective plants has been one year from receipt of contract, and one a month each thereafter. The two Government plants turn out on an average one large caliber gun a month from four to six months after receipt of forgings.

So that if Congress authorizes this year eight capital battleships or battle-cruisers, which will require ten or twelve 14-inch or 16-inch guns, the delivery of these guns will be a very serious problem, due to the fact that two years will be required on delivery of forgings, and the earliest possible date for delivery of finished guns would be at the expiration of four years.

There is a good field for other large manufacturers to enter into the coming building programme for the Army and Navy, not only in this particular work of gun manufacture, but in every branch which enters into the construction and equipment of a modern battleship.



12-inch coast defense gun mounted on a disappearing carriage, in normal position.

Varieties of Electric Motors

THE number of different kinds of electric motors has increased to such an extent that the lay reader has difficulty in understanding references to the various types of motors now in use. A complete explanation of all the different kinds would require much space, but an excellent summary occurs in a recent article by Mr. David B. Rushmore in the *General Electric Review* as follows:

Motors may, for convenience, be classified with reference to their speed characteristics as follows:

Constant Speed—Where the speed is constant or varies only slightly.

Adjustable Speed—Where the speed may be varied over a considerable range, but when once fixed, remains at this value, independent of the load changes.

Varying Speed—Where the speed changes with the load, usually decreasing as the load increases.

Multi-Speed—Where several distinct speeds may be obtained by changing the connections of the windings or by other means.

CLASSIFICATION ACCORDING TO CURRENT AND OPERATING CHARACTERISTICS.

Direct Current	Phase-wound
Series	Squirrel-cage
Shunt	Synchronous-Induction
Compound	Commutator
Differential	Series-Characteristics
Alternating Current	Shunt-Characteristics
Synchronous	Compound-Characteristics
Induction	

OPERATING CHARACTERISTICS.

Series Motors: The torque increases faster than the current and is a maximum at minimum speed. The speed varies with the load, being high at light load and low at heavy load. The efficiency is high throughout a wide range of speed as well as load.

Shunt Motors: The torque is directly proportional to the armature current, irrespective of speed. Approximately constant speed for all reasonable variations of load. Efficiency high throughout a wide range of load, but only for a small range of speed.

Compound Motors: Combine the characteristics of series and shunt motors, having a powerful starting torque and an increasing torque with decreasing speed. Speed not extremely variable under load changes, thus avoiding the danger of excessive speed at light loads.

Differential Motors: The series and shunt windings opposite each other, and these motors have, therefore, poor starting qualities. Speed increases with increase of load, but they have no tendency to run at dangerously high speed. Used only rarely for special applications.

Synchronous Motors: The speed of a synchronous motor is constant, being fixed by the number of poles and the frequency of the applied voltage. The single-phase type is not self-starting and requires some auxiliary motor to bring it up to synchronous speed and into proper phase relation before it can be properly connected to the supply circuit. The polyphase type has a limited starting torque, unless special features are added to assist its inherent starting characteristics. They are, therefore, usually provided with amortisseur starting windings; and the starting torque, due to the currents in this winding, is proportional to the square of the current induced and to the resistance of the winding. A motor of large armature reaction and high-resistance starting winding will have a high starting torque. The amount of load that the motor will bring up to synchronism and pull in depends also on the starting winding; but in this respect, a low resistance amortisseur winding is required to get the best results or the least slip, and from this standpoint high synchronizing torque is opposed to high starting torque, and *vice versa*. This factor is, however, not an especially difficult one to meet if the requirements are known beforehand, as it is seldom that the same motor will be called upon to start a heavy load and, at the same time, synchronize a heavy load.

The phase characteristics of a synchronous motor are of importance, as they show the variation in armature current for any given load with varying field excitation, and there is a certain field current at each load that causes a minimum current to flow. Any increase or decrease of field from this value increases the current and causes it to lead or lag in phase with respect to the line voltage.

Induction Motors, Phase-Wound: High starting torque with moderate starting current. Constant or variable-speed service, the latter being obtained by means of an adjustable resistance in the rotor circuit.

Induction Motors, Squirrel Cage: Constant-speed service with infrequent starting. Relatively small starting torque per ampere. By increasing the rotor resistance, thus decreasing the efficiency, it may, however, be built for high starting torque. Chief advantages are simplicity and durability.

Synchronous-Induction Motors: The same general construction as the wound rotor induction motor, the synchronous operation being obtained by exciting with low-voltage direct across one phase of the rotor winding. Better starting characteristics than the synchronous motor. The operation of the latter is, however, more stable under varying loads and fluctuating voltage, while it may be economically designed for power-factor improvements. Its cost is also lower.

A-C Commutator Motors: The characteristics of these motors are such that with suitable control they can be used in place of corresponding types of direct-current motors.

Consideration of the factors involved in a motor application necessitates a careful study, not only of the conditions under which the motor is to operate, but also of the characteristics of the motor itself.

Oiling on Earth Roads*

Presenting Suggestions for Obtaining Best Results

By B. H. Piepmeier, Maintenance Engineer Illinois State Highway Department

The oiling of earth roads has been practised on a small scale in a number of places for the past fifteen years. California has done more of this work than any other State, primarily on account of its natural resources and climatic conditions. It has used a large amount of oil and has successfully maintained many of its roads by this method, largely on account of the high grade oil that is available at a very low cost and also on account of the sandy condition of the soil, and the light winters that prevail.

Illinois can never expect to accomplish the same results in oiling earth roads as has California. The black, loamy soil, the low and poorly drained conditions of many of the roads, together with the severe winters and springs make it a fallacy to expect anything like a permanent road to result from the use of road oil.

It should be kept in mind that continued oiling will not make an earth road entirely satisfactory for all localities or for all conditions of traffic. The oiling of earth roads, like dragging, is a maintenance proposition. The intelligent use of oil, like the continued use of the road drag, will maintain the earth road so that it will materially improve the present conditions existing on many of the earth roads in Illinois.

The oiling of earth roads should not be practised promiscuously, but used only where the roads are suited to such work. The intelligent use of oils on many earth roads is unquestionably a justifiable expense.

It is the purpose of this publication to present as many facts concerning the use of oil as it is possible to secure at this time, also to describe what is shown by experience to be the best method of preparing the road and applying the oil together with a few suggestions that may be of some assistance to the contractor or individual who has such work under consideration.

THE SELECTION OF ROADS FOR OILING.

Roads should not be oiled until they have a permanently established grade; that is, all hills should be cut down, hollows filled, embankments widened, and all drainage structures established. Low, flat, undrained roads should not be oiled until proper drainage has been attended to. The oiling of a mudhole will not remedy the trouble, but often aggravates it.

Roads that have a preponderance of heavy hauling should not be selected for oiling. The oiling tends to waterproof the road, but it is readily understood that continued heavy hauling even on perfectly dry earth roads will eventually rut and dig them out in pot holes. The mixture of oil and earth lacks stability to meet all the requirements of traffic. If something could be mixed with the oil and earth to give it stability and aid it to resist the wear of traffic, it would more nearly meet all traffic conditions.

On moderately traveled roads where there is a greater amount of pleasure travel, the oiled earth roads will give better service.

THE PURPOSE OF OILING.

It should be kept in mind that the main purpose of oiling earth roads is to suppress the dust and aid in maintaining a smooth and waterproof surface. If it is possible to prevent dust from forming, the surface of the road will remain much smoother and there will be less mud formed during rainy weather. By reducing the mud nuisance it is possible to use the road a larger portion of the year. By keeping the surface of an earth road smooth, the traffic is distributed more uniformly over the road, thereby making it wear much longer. The suppression of the dust not only makes the road wear longer, but prevents a portion of the road from blowing into the adjoining fields, washing away, etc. The oil also prevents the encroachement of weeds and sod upon the traveled portion of the highway, thus improving the appearance and producing a more thoroughly compacted road.

A road that is oiled systematically for a series of years gradually acquires an oil-soaked crust which is more or less impervious to water. The heavy oil-soaked crust, however, will rut if the traffic is not distributed uniformly over the road and it will break through during the continued freezing and thawing of a severe winter and spring. This is particularly true if the road is used by heavy traffic. However, when such roads rut and cut through, they may be reshaped by use of the road drag at a very slight expense.

The purpose of the oiled earth road, therefore, is not to replace what is generally recognized as a hard surfaced road, but to keep the moderately traveled earth road in a suitable condition for ordinary traffic a larger portion of the year.

PREPARATION OF THE EARTH ROAD.

The mistake is often made of attempting to improve a road without first grading and draining it. When a road is graded for oiling, graveling, or any other form of surfacing, a permanent grade line should be established. Money spent in properly grading an earth road is not wasted, but has practically its full value when such a road is designated for later improvements. The great advantage of establishing a permanent grade and cross-section before the road is oiled is to utilize the oil-soaked crust of earth as a foundation for later improvements, such as gravel, stone, brick or other hard road surfaces. If oil, gravel, or other surfacing material is applied to an improperly graded road, a very large portion of the material will be disturbed and practically wasted when later improvements are demanded. In other words, any money that is spent upon the public highways should be spent with a view of further improvements that will naturally be required as traffic increases.

THE ROAD SURFACE PREPARATORY TO OILING.

As the prime objects of oiling an earth road are the suppression of the dust and the maintaining of a smooth waterproof surface, it is very important that the road surface be oiled when it is smooth, free from dust, and in a condition to absorb the oil.

Oil applied on dust will not penetrate the road surface, but will merely mix with the loose material to make an oiled-dust surface that is apt to fly readily and become a nuisance. The surface should be perfectly smooth and free from low places that will retain water. If water is allowed to stand upon an oiled earth surface, a bad mud hole will soon result. A moist subsoil preparatory to oiling is not serious though best results may be expected when the road is reasonably dry for about two inches on the surface.

APPLYING OIL.

After the road has been prepared as heretofore described, the oil should be applied at the rate of one fourth to one half gallon per square yard of surface. If the road has never been oiled, or if more than a season has elapsed since a previous oiling, it will be found that about one half gallon per square yard will be required. If the road or street has been oiled regularly, one fourth to one third gallon per square yard will be satisfactory. It is much better to apply a small amount of oil twice each season rather than to put on the full quantity in one application. When too much oil is applied, it is not only wasted, but is often very disagreeable to traffic.

After a road has been oiled for several years, one light application each year may be sufficient, or at least equal in results to two applications per year on a new oiled road.

The time for oiling will necessarily vary considerably, depending upon the season. Favorable times for applying the oil will be about April and September.

The uniform distribution of the material is one of the essential requirements for success. An ordinary street sprinkler or a home-made device attached to a thresher tank wagon or similar tank may be utilized for distributing the oil. An expert using such equipment can ordinarily get the required amount of oil on the road rather uniformly. Much better results, however, can be secured by the use of some specially designed apparatus made for the purpose, such as pressure distributor tank wagons.

SHIPPING AND HANDLING OIL.

Road oil is usually shipped in 8,000 or 10,000 gallon tank cars. Some companies are able to furnish 4,000 and 6,000 gallon tank cars, but such cars are very few and usually hard to get. The railroad tank cars are equipped with steam heating coils so the material may be heated in the tank by attaching a steam pipe or hose. Small quantities of oil may be purchased in molasses barrels, but when delivered in barrels there will be an additional cost of two to three cents per gallon. The tight barrels will ordinarily hold about 50 gallons. If the barrels are handled with care they can be sold at 50 to 65 cents each when empty. Heavy oil shipped in this manner is usually very difficult to remove from the barrels. In such cases the barrels are dumped into an open heating kettle and broken. After the oil is warm the staves and hoops may be removed by a large hoe or rake and used as kindling. The hot oil can be pumped from the heating kettles to the distributor and, while still hot, applied on the road.

Where there is no heating kettle on the job and there are but a few barrels of heavy oil to apply, they may be emptied direct into the distributing wagon by first placing the barrels in a very warm room or close to a fire for several hours.

Where there is but a small quantity of oil desired, say 3,000 or 4,000 gallons, it is usually cheaper and much more economically handled if shipped in a large tank car. Freight will have to be paid on a full tank car of 8,000 or 10,000 gallons, but this will ordinarily be compensated for by the saving in barrels and in the economy effected in handling the oil on the job.

HEATING OIL.

Where oil must be heated before being applied, it is often convenient to spot the car on a spur near some steam plant, such as a mill, creamery, or electric light plant. Where such arrangements can be made, a ¾-inch or 1-inch steam pipe line may be connected from the plant to the tank car. If no steam plant is accessible, an ordinary steam tractor or roller can be connected with the tank car. Where a steam connection is made for supplying the heat, from 12 to 24 hours are required to bring the oil up to 150 to 175 deg. Fahr. which is about the maximum temperature that can be reached with the steam heat. This temperature will permit the oil to be pumped readily. Its temperature may then be increased the desired amount in the distributor.

It is advisable to have a thermometer on the job so that the temperature of the hot oil may be tested from time to time.

Some road oils have a very low flash point and extreme care should be taken to prevent any oil from coming into contact with a flame. An analysis of an oil always shows the flash point, so it is well to keep the temperature somewhat lower to prevent burning and to be on the safe side.

The presence of a slight amount of water in heating oil will cause the oil to foam and give a great deal of trouble. Where the oil tends to foam, it should be heated very slowly. In such cases every precaution should be taken to prevent accidents.

SANDING OIL SURFACES.

Better results can be secured from sanding the road slightly after either hot or cold oil has been applied. Clean hard sand is much better on a road surface than dust or the sweepings from the road. A hot oil application should be followed with a light dressing of sand, or the traffic will likely pick up the oil and make the surface of the road very uneven. Sand may be applied at the rate of one cubic yard to each 100 to 150 square yards of road surface. It may be applied by shovels from a wagon or from a special apparatus for distributing the sand.

The application of sand gives an oiled earth surface more stability. The sand retains the oil, assists in preventing wear, and aids in keeping down the dust. The light application of sand is a justifiable expense on a majority of oiled earth roads.

OILING SANDY ROADS.

There are many sections of roads in Illinois that are very sandy and will have to be handled differently than the ordinary earth road. Where it is possible to mix clay or loam with the top four or five inches of sand before oiling, much better results may be expected. A suitable clay or loam can usually be secured at a reasonable distance from the sandy section. Where possible, the sand and clay should be thoroughly mixed and allowed to compact under traffic before the oil is applied. The sand-clay road will permit a slightly heavier oil than the ordinary earth road.

If there is no clay or loam within reasonable distance of the sand road, it may be materially improved by mixing a heavy oil (70 to 90 per cent asphaltic product) with four or five inches of the top layer of sand. This can best be done by applying about three fourths gallon of oil and then covering it with about one inch of the sandy soil from the road side, then applying about one half gallon of oil and another layer of sand. By building up successive layers of oil and sand, it is possible to get from one and one half to two gallons of oil per square yard of surface. This amount of oil mixed with four or five inches of the sandy soil will form a solid oil and sand crust that will hold up light traffic. The cost of such applications will vary from $800 to $1,500 per mile of road 15 feet wide.

The cost of applying a four or five-inch layer of clay or loam that may be secured within one mile of the road, and mixing it with the sand, will be about the same. It is generally recognized that the mixture of sand and clay is more serviceable than the mixture of oil and sand.

* *Bulletin* 11 of the Illinois State Highway Department.

THE COST OF SURFACE OILING.

The cost of preparing a public road for an oil treatment may vary from $100 to $2,000 per mile. However, the grading and preparation of an earth road should not be charged against the cost of oiling. The oiling or dragging of an earth road is a maintenance proposition and should be estimated separately from the building or preparing of the road. The road should be kept well shaped regardless of whether it is to be oiled or not. However, some cleaning is almost always necessary prior to the first application of oil, and this cost will vary from $25 to $50 per mile of road.

Road oil can be purchased for from three to seven cents per gallon, depending upon the quality. It may be applied on the surface of the road at the rate of one fourth to one half gallon per square yard. So the cost of oil alone may vary from $75 to $275 per mile of road 15 feet wide, depending upon the quality and quantity of oil applied.

The cost of applying the oil will vary, depending upon the length of haul and the kind of equipment used. This cost may be estimated at from $50 to $150 per mile of road 15 feet wide.

The above figures show the cost of oiling to vary from $150 to $475 per mile of road. With average conditions and with a medium priced oil, the average cost of oiling alone per application may be from $200 to $250 per mile of road 15 feet wide.

It is understood that the above figures are only an approximate estimate. A complete record of the cost of oiling, together with the quality and quantity of oil used each year over a period of years, is not available. The above figures, however, are based on the best information available in this and other similar States.

It is predicted by some enthusiastic users that a road will not require oiling after it has been oiled for two or three years and the surface has become thoroughly saturated with the oil. The writer has visited some twenty different towns that have oiled their streets for a period of more than five years and the present condition of such streets indicates that the oiling will have to be repeated each year indefinitely to secure the desired results. The quality or quantity of oil used in the twenty towns referred to is not known. It may be that if a high grade of asphaltic oil is used, some annual applications may be omitted after a few years of treatment. With the best oil, however, it is hardly expected that more than one year could elapse without some attention.

Some experiments have been made along the line of thoroughly saturating the top six inches of earth and then compacting it with a petrolithic roller. The saturating of the earth with the first application of two and one half to three gallons of oil was intended to resemble somewhat the continual oiling of the surface over a period of four or five years. The experiments referred to were made in 1908 and 1909 on three different sections of road of one half to three fourths of a mile in length. Two of the sections were considered failures and were within three years covered with a more desirable wearing surface. The third section still remains; however, it shows very few signs of having such a treatment. This section seems to rut in the winter and spring almost as badly as the other portion of the road; in midsummer the surface of the road pulverizes and forms a dust that flies almost the same as dust from other portions of the road.

In view of all the information that is available on oiled earth roads, indications are that the treatments must be made each year or at least every other year to get the desired results. On this basis, $150 to $200 per year for five to ten years may be a basis for estimating the cost of surface oiling.

QUALITY OF OIL.

On practically all work that has been done in the past, a light oil with a paraffin or semi-asphaltic base has been used. There is very little information available on the use of the higher grades of asphaltic oil on earth roads. It is predicted by our best authorities that the use of the higher grade asphaltic oils will prove to be more satisfactory and more economical in the end than the use of inferior products.

It seems to be the unanimous opinion of all extensive users of road oils that the semi-asphaltic products are far superior to the paraffin oils.

From the information that we have, therefore, it seems essential that careful analysis be made of all road oils before using and that preference be given to the natural and semi-asphaltic products over the paraffin oils.

The best products are secured only by purchasing the material under carefully drawn specifications and using the same under the approval of a competent chemist.

The amount of asphalt or residue that a product may contain does not classify it as a suitable material for the road under consideration. For instance, a thick heavy material with 40 per cent asphalt or residue will not give the same results as a light thin product of the same asphaltic content.

The purpose of oiling an earth road is the suppression of dust and the waterproofing of the surface. It is evident, therefore, that the best results may be secured during the first application, by applying either a cold oil or at least a very thin product that will penetrate the surface of the road several inches and at the same time contain as many binding elements as possible so as to seal all pores in the earth, making it waterproof and at the same time adding some binding qualities that may assist the bond of the soil itself. A suitable product, as is commonly expressed, may vary from 30 to 60 per cent in asphalt. After the surface of the road has been thoroughly saturated, a hot oil or a slightly heavier product may be used.

If the heavier oils are used for the first application they will not readily penetrate the surface of the road and will consequently form a mat on top. The forming of the mat before the surface of the road is more or less waterproof may be a serious fault as moisture will accumulate beneath the mat and the road will be much slower in drying out than it would had the oil not been applied. The mat surface with a soft subsoil will rut more readily, besides breaking and scaling off in large pieces, making the road surface rough and undesirable.

The paraffin oils are ordinarily thin and light, yet they do not contain sufficient binding elements to seal and hold the surface of a road. Such oils after being in use a short while apparently have very little value as they permit the surface of the road to grind up into a light oil-mixed powder which makes a slick, slimy mud when wet, and which, when dry, flies almost as readily as the ordinary dust. The oiled dust becomes very disagreeable when it flies. It dulls the glossy finish on vehicles, makes the eyes burn and almost ruins clothing and household furnishings. A number have remarked that a poorly oiled earth road is much worse than no oiled road.

OILING GRAVEL AND MACADAM ROADS.

Gravel and macadam roads that are in good shape may be economically maintained by applying a surface treatment of oil or tar. Where gravel or macadam roads are subjected to a large amount of motor traffic, they soon become very rough and begin to ravel. This is largely due to the fast motor traffic that whips out the bonding material that holds the stones or pebbles in place on the surface of the road. To maintain such roads, it seems necessary that some bituminous products be applied occasionally to the surface of the road to retain the bonding material and to prevent rapid deterioration of the road.

Experience shows that more care should be taken in the preparation of the road surface and in the selection of the quality of bituminous products than in the oiling of earth roads.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

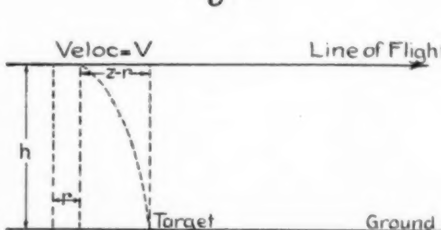
Dropping Bombs From Airships

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In the SCIENTIFIC AMERICAN SUPPLEMENT of February 5th, the article by Alexander Buttner on "Throwing Bombs from Airships" does not take into consideration the resistance of the air. This resistance varies as the square of the velocity, and the actual retardation is affected by the shape, size, and weight of the object thrown.

But for any object, the resistance soon causes a retardation equal to the acceleration of gravity, after which the velocity or space traveled in each successive second is constant.

Fig. 1.

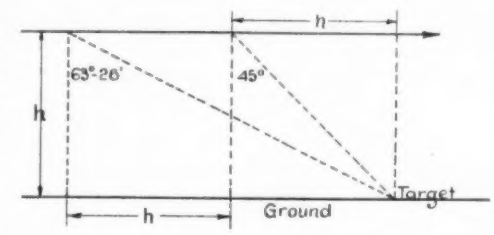


Haswell, page 949, gives the retardation for the first three seconds of a lead ball weighing one pound, but I have been unable to find any data of the actual time taken by a heavy object to reach the ground when dropped from any considerable height.

A bomb dropped from a height of 800 meters will take more than twelve seconds to reach the ground, during which time it will travel a horizontal distance equal to the speed of the airship, multiplied by the time of fall, minus the horizontal retardation due to its horizontal velocity, and the tangent of the angle of the telescope will be $\frac{l-r}{h}$, as shown in Fig. 1 of the accompanying diagram.

If you have a telescope mounted on a vertical arc, it is possible to predetermine the actual speed of the airship over the ground, by observing the interval of time between the target bearing 63 degrees to 26 degrees and 45 degrees from the vertical. During this time the airship has traveled a distance equal to its height above the ground, and its speed is easily determined. Moreover, you are still horizontally distant from the target h, your height, and the bomb can be released by setting the telescope to the angle whose tangent is $\frac{l-r}{h}$, and releasing the bomb when the target crosses the line of sight, or the time it takes the airship to travel the distance $h-(l-r)$ or $h+r-l$, at its determined velocity, can be tabulated, and the bomb released this number of seconds after the second observation for speed. Fig. 2.

Fig. 2.



The height of the airship is given by the barometer reading, which can be corrected as often as necessary by observing the distance of some object passed over, with a binocular range finder.

The telescope arc can be maintained vertical by the use of a gyroscope.

Such an instrument would be invaluable in indirect firing, or spotting in naval engagements.

Norfolk, Va. C. S. STARWORTH.

Flower Color

MANY students have doubtless observed that one of the commonest flower colors is a sort of purplish pink that often just misses becoming a distinct rose or a decided red. As a matter of fact, good reds and pinks are comparatively rare in any flora and the reason for this is coming to be well understood. The normal color of the pigment which produces both red and blue flowers is this same purplish pink. When the sap of the plant is alkaline this purplish pink turns to blue and when it is acid the flowers become pink or red. When this is realized, several other peculiarities of flower color become intelligible. For instance, there are many blue flowers, such as the lungwort (*Mertensia Virginica*) which are pink in the bud. As the flowers open and oxidation processes reduce the acidity of the cell sap, the pink must of necessity become blue. This also explains why so many blue flowers have pink counterparts or the reverse. Let a strain with a tendency to acid cell sap appear in a race of blue flowers and its blossoms are likely to become pink or red. The rose-colored variety of the common New England aster may be explained in this way. There are also many white flowers that are pink either at the beginning or end of their period of bloom. Apple blossoms, and the flowers of the white trillium and cotton will come to mind in this connection. In these flowers it apparently needs but a slight increase or decrease in acidity to develop or destroy the color. We do not, however, have to depend upon instances like these to substantiate our theories regarding changes in color. Almost any pink or blue plant juice may be used to demonstrate the facts. Anyone who will boil out the color from a purple cabbage may turn the juice blue by the addition of a few drops of ammonia or a little baking soda and restore the original pink color by adding a few drops of vinegar or other acid. Beet juice and most of the fruit juices act in the same way and it is therefore not surprising to find that the familiar litmus paper so commonly used in testing for acids and alkalies is made by dipping strips of paper in the juice of certain lichens. Many pink flowers may be turned blue by exposing them to the fumes of ammonia for a few minutes and blue flowers become pink when exposed to acids. In making these experiments, however, one is often astonished to find the color change produced is neither pink nor blue, but *green*, a fact which opens up other avenues of speculation, but in all of which we discover how cleverly nature produces a variety of effects with almost identical materials.—*The American Botanist.*

The Care of the Feet*

The Injuries Resulting from Improper Shoes

The importance of the foot as the weight-carrying foundation of the human body is far from being properly appreciated. Its soundness and lack of sensitiveness, which are conditions for its efficiency, are a necessary concomitant for that joy in bodily movement which is as essential to our internal organs as to our ease of locomotion, just as nourishment is essential to the body as a whole. Motion is life; cessation of motion is death.

But how badly the feet are treated by the majority of people, partly from ignorance and partly from a foolish vanity, by shoes too short or too narrow, now with heels too high or again without any heels at all! What mis-shapen and deforming shoes they dare offer to our women and girls, even in this grave time of war, when it is every man's duty to make himself strong and efficient, is shown by the accompanying Figs. 1 and 2, which were seen recently in the advertising pages of a widely circulated paper. And the

Fig. 1.

worst is that, as a glance at the people moving upon a city street shows, crowds of these have bitten at that injurious bait.

The fashion in shoes, which has been spreading for years, has two objects: to make the body look larger and the feet smaller than they really are (see construction in Fig. 7, the sole being about 5/6 of the length of the foot within). Here too in things which are perhaps of wholly minor importance, the German woman should set up a standard of honesty and not be guilty of any attempts at any misrepresentation of facts. All the more so since she cannot succeed in the attempt. Injurious shoes are a very poor means of

Fig. 2.

improving the appearance. A large body and a small foot do not follow the laws of beauty, which first of all demand a pleasing proportion, any more than a small body and a big foot.

If a woman wishes to perfect her appearance she can accomplish that honestly and effectively by com-

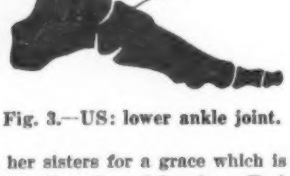


Fig. 3.—US: lower ankle joint.

peting with her sisters for a grace which is built upon elasticity, strength and good bearing. To be beautiful means first of all to be healthy. Everything which can promote beauty must promote health, especially is this true of regular gymnastic exercises.

The present questionable fashion in shoes, however, injures the health, deforms the body and prevents elasticity of movement and good carriage. The chief fault of a modern shoe is the mis-shapen heel, which is too high, pushed too far forward and too small on its under surface (Figs. 1 and 2).

A heel of the right height, that is not over one and one fifth inches, placed in the proper position under the foot and broad enough to give security to the step, plays no mean part in the preservation of a sound foot, for a moderately high heel protects to a certain extent against the commonest foot disease, in fact, the commonest disease in general, flatfoot. This protection is based on the fact that moderately high heels have a tendency to make the foot toe-in, and, this lifts in a measure the inner edge of the foot and gives flexibility and play to the lower ankle joint (Fig. 3). Flatfoot is caused by opposite conditions. Moreover, with the toe-in position the relations of body weight to the arch

Fig. 4.

of the foot become such that it is more advantageously placed. On the other hand, the relations of weight to anatomy are such that heelless shoes, like sandals or slippers, are harmful, especially when the knees are bent (Fig. 4).

If heels higher than the height given are used—and I have found them to measure two inches or more—the foot is in danger of straining toward inner or outer side. This tendency is increased should the heel taper downward. The reason for the added danger,

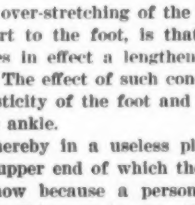


Fig. 5.

which lies in the over-stretching of the ligaments lending lateral support to the foot, is that the high heel of the shoe causes in effect a lengthening of the heel bone downward. The effect of such conditions is likely to be an over-elasticity of the foot and possibly sprain or fracture of the ankle.

There arises thereby in a useless place too long a lever-arm at the upper end of which the weight of the body falls. If now because a person fails to take especial care in walking, or because the heel is run-over, the lever arm becomes oblique, the line of gravity of the body no longer falls within the lower heel sur-

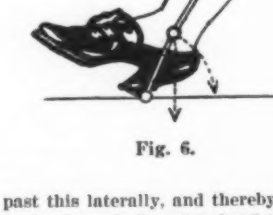


Fig. 6.

face, but past this laterally, and thereby the upper end of the elongated lever is forced to bend to the side.

Accidents are the more likely to happen the less support the foot has in itself. With women and young girls one finds comparatively frequently an abnormal flexibility of the feet. When such persons wear high, narrow heels the feet are likely to tilt outward at every step, a condition which earlier or later must lead to flat-foot because at every step a part of the support of the foot is lost by over-stretching of ligaments, which are already excessively relaxed.

A further danger arises for the wearer of modern shoes from the fact that the back ligament of the heel is unnaturally shoved forward when in taking a brisk step the ankle bone touches the floor as usual with the back edge of the heel first. It can easily happen that when the weight of the body is carried over upon the foot, the lever arm lengthened by the high heel and pushed forward at its lower end does not bend forward as is desired, but backward. Under these circumstances the front part of the foot would bend upward instead of downward, and not come to rest until the back surface of the heel approaches the ground. The foot cannot help being harmed by such upward tipping through over-stretching of its back supports (see Fig. 6).

In order to avert these injuries threatening her at every step, the wearer of modern shoes is forced to

Fig. 7.

walk very carefully in order to tread with the sole of the foot as flat as possible. She accomplishes this by taking mincing little steps and at the same time keeping the joints in knee and ankle bent.

This gait and this posture are characteristic of the wearer of modern shoes. In addition it is difficult because it is more of a strain to keep the body erect when the hip joint is bent. For just as in sitting so in the bending of the hip joint, the pelvic cavity is decreased. Thus to the ugly position of the leg a further ugliness is added, a rounding of the back, by which means a pitiful figure is presented.

This posture is assumed not only in walking, but in standing; for on account of the increased demand upon the strength it is impossible for any one whose feet are kept by high heels in an unnatural position to hold knee and hip joints stretched and the body upright. A kind of military stiffness would have to be assumed, which can be done by our women only in the rarest cases and then never for long. So the wearer of high heels has ordinarily a standing position which is bent and unlovely.

The evil results of high heels are not yet exhausted. The higher the heel the more inclined is the plane upon which the sole of the foot rests. The foot can stand a slight lifting at the back without slipping forward, but this slipping regularly occurs when the height of the heel is more than one and one fifth inches. The result is that the toes are pressed against the leather, which incloses the foot too tightly. From this corns occur, also an outward bending of the great toe caused especially by tight shoes. This circumstance brings about, therefore, a weakening of the important muscles of the great toe and a painful curling into a ball of the inner front part of the foot, and sooner or later, flatfoot. Likewise the arch, which under normal conditions the foot raises diagonally in its forward part

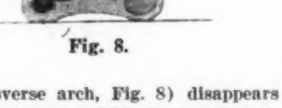


Fig. 8.

(see front transverse arch, Fig. 8) disappears under the heightened pressure, which is transferred to the front part of the foot by the slipping forward of the foot. By this the club-shaped outer ends of the central bones of the foot are pressed constantly against the sole of the boot.

The arch disappears and callous places develop on the sole of the foot in front, which may be very painful. All these injurious disturbances against which pedicure is more or less helpless lead now to a further evil, namely, an increasing degeneration and decay of the foot. Largely on account of the constant pain walking becomes a burden and is more and more limited.

The lack of exercise tends to increase the weight, which the painful feet weakened by inactivity have to bear. Thus a vicious circle is developed which not only

* From *Die Umschau.*

ruins the motor apparatus before its time, but works in increasing measure to weaken the heart and internal organs.

Any one who observes carefully our women over forty will be struck by their lack of elasticity. Just notice, for example, what effort it costs many women to climb stairs. The loss of strength in their feet they seek to make good by help from their arms with cane, umbrella, stair rail, etc.

Let this deformation of the feet be met by reasonable and regular care of the feet. The task is not only to protect the foot from harm by properly constructed shoes, but to make it strong and able to meet the demands of life on into old age.

In contrast to the mincing gait and the walk on the back part of the foot, which does not bring into play the important front muscles, the walk with swinging strides and the proper use of the whole foot brings to them agreeable and strengthening stimulation. The slow stride of our schools for recruits represents this activity in slow tempo, and as is well known, is an excellent means for attaining a good bearing and control of important portions of the organs of motion, as well as for preparation of the feet for long marches. The following may be regarded as possible daily exercises: Rolling of the feet, raising and lowering of the heels, as well as of the inner edge of the foot, standing, walking and hopping on the toes, bending and stretching the knee, jumping exercises, for example in climbing stairs, etc.

Whoever by correct use of his feet and by such exercises as can be fitted frequently into the tasks of the day, makes and keeps his feet sound, does not need to worry for fear they may fail him in old age as is often the case with our fellowmen. He will preserve his joy in bodily exercise to the end of his days.

Now that corsets, hoopskirts and similar instruments of torture are disappearing more and more, may the knowledge become widespread that the foot cannot be abused with impunity. And may our women give to those shoe manufacturers who put such dangerous objects on the market the answer they deserve.

Detonation of Submarine Mines by Electricity*

SUBMARINE mines are of two types. Those of one type are allowed to float and drift submerged in the open sea or in ship channels. Those of the second type are anchored so as to form part of the defenses of a port and are controlled from a distance. To detonate the latter electricity is generally used. The following is from an article by M. Antoulaeff, professor in the Petrograd Military Electro-technical School, published in the Russian journal *Electritchestvo*.

Considerable progress has been made in the matter of anchored mines since the time when electricity was first adopted as a means of ignition. There is generally a device inside the mine which closes a circuit when the mine is struck by a ship. The current then passes through the detonator, the essential part of which is a platinum wire surrounded by a sensitive explosive. But the circuit can be opened at the shore station so as to render the mine harmless to friendly vessels.

The current is sent through from the shore station by means of a cable. Fig. 1 is a diagram showing the layout. A and B are the terminals of the interior conductor and

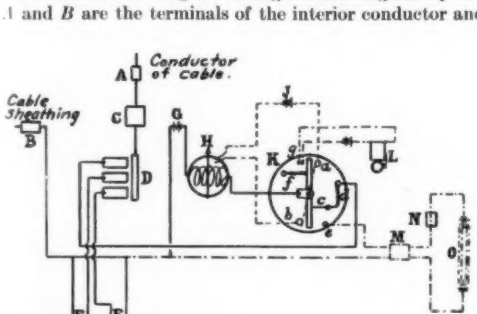


Fig. 1.—Electric connections for the automatic detonation of submarine mines.

the exterior sheathing of the cable respectively, C is the annunciator board, D the switchboard, E and F the two pairs of terminals, H an ordinary galvanoscope whose needle, by deflecting from its position, makes a contact between two springs, K a relay consisting of an electro-magnet with poles a and b and an armature swinging on a pivot. So long as the armature occupies the position shown, the lever c cannot move, in spite of the pull exerted upon it by the spring d, on account of a notch in the armature which holds it. N is an instrument to record the number of times the circuit is closed. O is the battery supplying the detonating current.

When a boat strikes a mine a short-circuit is produced between the cable sheathing and the cable conductor, current flows from the auxiliary battery G, the needle of the galvanoscope deflects and touches the two springs at the same time. This closes the circuit through the relay, the armature of the electro-magnet is attracted by the poles and turns in a clockwise direction. The lever c, actuated by the spring d, moves into contact with the pin e. The contact between the armature and the lever c is thus broken and the current is interrupted. The needle of the galvanoscope returns to its initial position and the contact between the springs of the relay is broken. The relay circuit being thus broken, the armature is drawn in the opposite direction by the spring f and short-circuits the terminals g, causing the bell L to ring.

When the double-pole switch M is closed and the lever c is held in contact with the pin e by the spring d, the detonating current passes through the terminal of the battery O, the instrument N, the switch M, the pin e, the lever c, the spring d, the switch D, the annunciator C, the terminal A, the conductor of the cable, the detonator of the mine short-circuited and its connections, the shell of the mine, the sheathing of the cable and the water, the bonding point, the switch M, and, finally, the second terminal of the battery. Under the action of the current the detonator explodes.

Mines are generally connected in parallel. Each one is equipped with a cut-out apparatus to open the circuit after the explosion and record the number of the exploded mine. The principle of this device is as follows (Fig. 2):

There is a disk A which is turned in a clockwise direction by springs and gears (not shown in the figure). On the upper surface of this disk is a tongue a attached to an ebonite ring c; on the lower surface are several metal contacts b equal in number to the number of the corresponding mine less one. These contacts are connected to the axis of the disk, which in turn is connected to the sheathing of the cable.

When the shunt circuit is short-circuited at the mine the detonating current flows from the shore station to the point p, then through the coil of the electro-magnet, the axis of the armature d, the tongue a and the mine, and

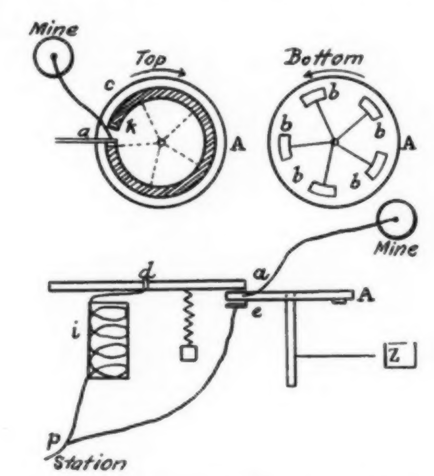


Fig. 2.—Device for recording the number of the mine exploded.

returns through the sheathing of the cable. The passage of the current causes the following results:

1. The armature deflects, its right-hand end rising and releasing the disk.

2. The disk begins to revolve and the current in the circuit p, i, d, a is interrupted, since the right-hand end of the armature slides on the ebonite ring until the latter is stopped by the projection k; but in the course of this rotation the contacts b touch the spring e successively, and the detonating current passes into the cable sheathing five times by way of p, e, b.

Consequently, if mine No. 6 explodes, for example, the detonating current flows six times through the circuit before the latter remains permanently open, and the number of the mine is recorded by the instrument N.

*Génie Civil.

Spectacled Soldiers*

A QUESTION which is now engaging the attention of recruiting officers across the sea is the advisability of allowing men who wear glasses to enlist in the army. Should the United States become involved in this or any other war, this problem would be presented to our army, and more particularly to the army medical officers. It might indeed assume grave proportions with us on account of the prevalence of visual defects among Americans. An argument against enlisting such men, which will at once occur to military surgeons and to other physicians who have attended men in prisons or other places where there was a temptation to avoid duties of various kinds, is the ease with which men with glasses may avoid active duty, if they are so inclined, by simply breaking or losing their glasses. Then, of course, these accidents may actually happen and deprive the army of the recruit's services for a period if the visual defect be of such a degree as to incapacitate him.

Another factor which must be taken into consideration is the severe character of wounds of the orbit in soldiers wearing glasses. This peculiar susceptibility of spectacled men is recognized by the laws of most communities which provide for a harsher penalty for one committing an assault on a man with glasses than on one without. It is also considered hazardous for such a man to play professional baseball, so much so that we find in the two major leagues, employing between three and four hundred players, only one man with glasses, and he is regarded as something of a curiosity, being the only one of the sort for a number of years. A projectile striking a pair of glasses with considerable force would drive the splintered fragments of glass directly into the brain, inflicting an almost necessarily fatal wound. This is not pure hypothesis, for since the present war began we have received frequent reports of severe injuries sustained by officers wearing wrist watches which came into contact with flying pieces of shell or bullets. Even those in the immediate vicinity of soldiers wearing glasses might be endangered by the fragments of glass, just as is the case now with wrist watches.

Of course there will be some applicants for enlistment who will be desirable on account of special knowledge or because they have had experience which fits them for certain departments of the army, even though they are handicapped by some visual defect. Then, too, the exigencies of the situation may become such that disabilities of this kind will have to be waived. The whole matter will, of course, be decided by the military authorities, but it seems that the opinion of the medical profession, which will undoubtedly be asked, will be against the enlistment of men with glasses on account of the ease with which they may malinger, their ability to become incapacitated by accident to their glasses and the peculiarly severe nature of the wounds which they may sustain.

* From the *Boston Medical and Surgical Journal.*

Making Compressed Hydrogen

AN interesting process for making compressed hydrogen of great purity is described in *Zeits. f. Komprimierte Gase* by F. Bergius. The gas is generated by the action of liquid water on powdered iron at a temperature of 350 deg. Cent. and under a pressure of 300 atmospheres in a vertical steel cylinder, which stands in the furnace and is charged with iron and water from below. In the experimental apparatus of 100 centimeters capacity hydrogen free from steam continuously escapes. In the technical apparatus the gas passes first up a vertical condenser; no steam is said to escape then; there is, however, a water separator in the pipe which leads to the valve and to three steel bottles of 30 liters capacity in which hydrogen collects at 150 atmospheres. In the laboratory plant the complete reaction would take 7 hours; about 90 per cent of the water is, however, decomposed in 4 hours, and technically the operation is interrupted at that stage. That is to say, after about 5 hours the heat is turned off, and the apparatus is emptied when the pressure has fallen to atmospheric; the iron, which has been oxidized to Fe_3O_4, is dried and reduced by means of coal; thus a very porous iron is obtained, suitable for further use. The hydrogen of 99 per cent can further be purified to 99.95 per cent by being passed through charcoal. The liquid water does not attack the sulphur in the iron; but it does attack the carbon, and some saturated and unsaturated hydrocarbon and a little CO are formed; this can only be proved by liquefying all the condensable gases, contained in very large volumes of hydrogen, by means of liquid air.

Type Setting in Japanese

THE publication of newspapers in either the Japanese or the Chinese language has always been difficult on account of the great number of characters employed, but the publisher of a Japanese paper in Honolulu is said to have reduced the 5,000 characters heretofore used to less than one hundred, and to have devised a machine by which newspaper composition can be readily set in these characters. The machine is said to be equally available for setting matter in Chinese.

Injuries Due to Radium*

Reports of Typical Cases and Recommendations for Prevention

By Thomas Ordway, M.D.

During the past two years, the Cancer Commission of Harvard University has been engaged in obtaining data concerning the therapeutic value of radium. Owing to the great variety in type of lesions to be treated and in their distribution, the methods of application have been varied, chiefly as to differences in filtration and protection. This has necessitated in the application the frequent manipulation of highly radioactive tubes and applicators.[1]

Rutherford[2] says:

"Walkhoff first observed that radium rays produce burns of much the same character as those caused by Roentgen rays. Experiments in this direction have been made by Giesel, Curie and Becquerel and others with very similar results. There is at first a painful irritation, then inflammation sets in, which lasts from 10 to 20 days. This effect is produced by all preparations of radium, and appears to be due mainly to the alpha and beta rays. Care has to be taken in handling radium on account of the painful inflammation set up by the rays. If a finger is held for some minutes at the base of a capsule containing a radium preparation, the skin becomes inflamed for about 15 days and then peels off. The painful feeling does not disappear for two months."

Although these rather *acute* reactions due to radium are apparently well known to *physicists* working with radioactive substances, and considerable experimental work has been done on animals by biologists, very little attention has been paid to the more chronic changes. The purpose of this paper is to record a detailed description of symptoms and signs from the *clinical* point of view, and to emphasize the importance of these as occupational injuries, so that more serious effects may not result in those engaged in the application of radium as a therapeutic procedure.

Personal observation in London and Vienna and in Germany while I was investigating the status of clinical work with radium has led me to note the possibilities of discomfort and injury from contact with radioactive substances.

In London at the Radium Institute the plan was adopted of rotation in service each month for the nurses handling the applicators. Attention had been called to the effects on the fingers of those handling the radium by sensory disturbance in the form of pain and anesthesia, first noticed by the difficulty experienced in preparing eggs at the table according to the English custom. This may seem a trivial instance, but it well illustrates a peculiar sensitiveness to heat and the difficulty of delicate manipulation with the affected fingers.

On the other hand, severe injury was observed in Vienna in the case of one who had handled large quantities of radium. The thumb, forefinger and middle finger of the left hand showed severe lesions, particularly in the form of atrophy and intractable ulceration.

In Paris at the Laboratoire biologique du radium, particular inquiry was made as to the effect of radium on the hands, and it is interesting to note that one of the attendants who had been making almost daily surface applications for over two years had up to that time experienced no injurious effects whatever. This is probably due in part to the type of applicators used in this clinic.

From this it will be seen that injurious local effects were anticipated so that the changes to be described were not acquired unwittingly but in spite of caution. The increasing use of large quantities of radium warrants a detailed description and record of these changes, not only because of the annoyance and discomfort caused, but also as a warning from analogy to the Roentgen ray of more serious late effects, such as atrophy, intractable ulceration and even cancer.

Already in certain instances there has been caused not only great annoyance from discomfort, but actual impairment in manual dexterity in performing delicate manipulations because of persistent local anesthetic effects.

Throughout the first year of the radium work at the Huntington Hospital, a considerable proportion of the applications were made by the physician in charge. As a result of manipulation due to the clinical applications of radium in the variety of cases referred to above, a few weeks after beginning there was noticed slight though gradually increasing sensory disturbance in the finger tips, particularly on the ulnar side of the first phalanx of the thumb and the radial side of the terminal phalanges of the index and middle fingers of each hand.

These symptoms occurred very insidiously, and consisted of blunting of sensibility of the finger tips, paresthesia, such as increased sensitiveness to heat and pressure, amounting at times to actual pain, and anesthesia of varying degrees.

The subjective disturbances were out of all proportion to the objective findings, which included flattening of the natural ridges on the affected fingers with consequent changes in the characteristic markings of the finger prints, thickening of the horny layer of the epidermis with scaling, failure of the tips of the fingers to resume their normal shape after pressure, a sort of pitting, and upgrowth of the cuticle at the base of and underneath the nails, which were easily cracked, extremely brittle, and tended to stand off from the fleshy part of the fingers.

Each assistant and nurse before engaging in the clinical application of radium was warned of the annoying and possibly dangerous effects, and told not to handle the active tubes of emanation with the fingers, but to make use of forceps. In spite of this, a certain amount of handling was unavoidable in changing the radium tubes for suitable filtration and protection in the different cases.

Nurses and assistants, and also members of the commission, have been asked to describe carefully and independently the subjective and objective changes produced. The onset, variety and annoyance of the effects may be best understood and appreciated by the individual descriptions to be cited, for the most part in the sequence of their occurrence.

Case 1 (C. O. 15.20).—A physician began making routine applications of radium during the early part of November, 1913. These continued in increasing numbers until the latter part of January, 1914. Since that time, applications have been made only in special cases.

After a few weeks the tips of the thumbs, particularly toward the ulnar side, and the fore and middle fingers, especially toward the radial side, gradually became numb and felt unnatural from the blunting of sensibility. They were very tender on pressure, so that buttoning small buttons under pressure was not only difficult because of the anesthesia, but also painful. Hyperesthesia was also noted in a markedly increased sensitiveness to heat. There was paresthesia in the form of a peculiar unnatural feeling of the finger tips and awkwardness in using the fingers for delicate manipulation. Because of the anesthesia, small objects were frequently dropped, and difficulty was noted in taking pulses with the affected finger tips, which are those commonly used. These subjective symptoms have been very pronounced, persistent and out of all proportion to the objective findings.

The affected portions of the fingers described above became smooth and shiny, and the ridges giving the characteristic finger prints became less marked and almost obliterated. Later the epidermis was thickened, dry and parchmentlike, and on pressure the pad of the finger tip remained indented for some seconds instead of immediately resuming its rounded form.

The thickened horny layer became wrinkled and cracked, and scales of varying size repeatedly desquamated. The nails stood off from the fleshy part of the affected fingers, and there was a marked tendency for the upgrowth of the tissue beneath the nail.

At the present time, although the patient has actually handled the radium for clinical application only occasionally for almost a year, the pain, tenderness and sensitiveness to heat and the objective signs have largely disappeared; notwithstanding this interval, the dryness, parchmentlike feeling, partial anesthesia and slight tenderness of the affected finger tips persist.

Case 2 (C. O. 15.21).—A nurse began making routine application of radium in December, 1913, and continued this until the last of February, 1914. After that time occasional applications were made with an interval of three months on vacation. "Two weeks after first handling the radium tubes, dryness of the skin was noted. A little later the flesh on the finger tips of both hands, especially the thumbs and forefingers, looked yellow and was easily indented on pressure. In about a month the skin over the finger tips began to crack and peel, and the dryness of the skin extended down the fingers to the palms of the hands. The flesh grew more rapidly than normally at the base of and below the free edge of the nails, which became very brittle. Numbness developed in the finger tips of both hands, awkwardness in picking up articles, pain on buttoning clothing, sensitiveness to heat, and later hot throbbing sensations extending the entire length of the fingers on handling radium. At present there is no tenderness, but marked paresthesia and slight anesthesia, slight peeling, dryness and marked numbness of the tip of the thumb, index and middle finger of each hand. Great annoyance is caused and difficulty in delicate manipulation."

Case 3 (C. O. 15.22).—A nurse began making routine clinical applications of radium in February, 1914, and continued until June, 1914.

"After a few weeks the tips of the fingers became yellowish-white, gradually growing whiter until the fingers looked as if they had been burnt. The skin about and under the nails hardened and grew thicker. The fine lines on the finger tips began slowly to disappear, leaving the tips tight, white and swollen. The finger tips remained white, and minute cracks appeared. Then from the whole tip of the fingers the skin peeled off, leaving the ends smooth, pink and shiny.

"The tips of the middle finger and thumb of the left hand again became swollen and hard; the thumb appeared yellow, as if calloused; the skin is dry and cracked, and there is a spot on the thumb 1 by 2 centimeters that is red and smooth where the upper layer of skin is cracked and peeled off.

"The left forefinger is swollen, hard and yellowish-brown, with minute cracks, as if the skin were too tight; the fingers are not wholly straight, but curved a bit toward the palm. The nails seem to stand out from the fingers. The cuticle is dry and white, cracked in some places and inclined to grow down around the nail. The fingers tips dent on pressure.

"Subjectively it is noted that the fingers were sensitive to pressure, especially on the nail. They gradually became stiff and were tender on bending. Definite pulsation was felt about a month after first using the radium. The fingers were very hot, and felt much as a mildly septic finger feels; they gradually became oversensitive to heat, and the sense of touch was not so sure. Articles would drop from the fingers.

"This has been persistent up to the present time, and it is hard to pick up pins or button anything. Pressure on the nail and on the very tip of the finger is painful. The fingers feel very hard, stiff and awkward. It is difficult to tie and loosen hard knots. The hand is dry and rough, and feels big."

Case 4 (C. O. 15.23).—An assistant, medical student, began making routine clinical applications of radium June 3d, 1914. "The work consisted in transferring glass capillaries of emanation from one steel jacket to another, or to flat applicators in fixing silver sheaths over the steel, in arranging a number of steel tubes between pieces of lead, paper and gauze and then wrapping all together in rubber sheeting and adhesive. Tubes of emanation were also placed in various special applicators. In unscrewing the tubes they were held in dressing forceps by the left hand, and the points and eyes were held by the right hand occasionally between the thumb and forefinger, but always straight half length hemostats. The applicators were held in the left hand and fastened with adhesive by the right hand. Glass capillaries have never been picked up or held by the fingers, and only rarely in the early part of the work were the steel tubes so held, and then for not more than a few seconds. The number of applications per day has varied from 5 to 16, average 10. This indicates approximately the number of times a day that the tubes were handled or changed.

"During the first three weeks there was no noticeable effect. Then gradually the tips of the thumbs and index fingers assumed a smooth, shiny appearance, with flattening of the ridges. This became noticeable at the end of the fourth week. Up to this time there was no unusual sensation. During the fifth week a very thin layer of epidermis loosened and peeled off the tips of the thumb and index fingers from the nail to half way to the second phalanx; this scaling took a week, during which the finger tips affected became somewhat swollen, and there was a sense of fullness in them They were warmer to touch than the other fingers of either hand. There was slight sensitiveness to pressure

* *The Journal of the American Medical Association.*

[1] Ordway, Thomas: "The Use of Radium in Cancer and Allied Conditions at the Huntington Hospital," *Boston Med. and Surg. Jour.*, November 19th, 1914.

[2] Rutherford, Ernest: "Radioactive Substances and Their Radiations," New York, G. P. Putnam's Sons, 1913, p. 327.

and a tendency to drop small objects, such as pins, if picked up in the usual manner. During the sixth and seventh week the fullness and discomfort disappeared. In the eighth week the swelling increased and the skin became tense; the sense of fullness returned, and pain was experienced on touching a small object, such as the head of a pin. There was also some difficulty in picking up small articles and holding them, especially if not directly thinking of them. After the eighth week of making radium applications a vacation of two weeks was taken; during this time, in which no radium was handled, the outer layer of skin on the affected finger tips again became white, hard and peeled off, leaving the fingers much more sensitive to pressure, either gradual or sudden, and to heat. Indeed, severe pain was felt when taking up a cup of hot coffee, a heated test tube or on washing the hands in water of such a temperature as was not at all painful to the unaffected parts of the skin.

"Similar process of swelling of the finger tips, hardening of the superficial layers, cracking and peeling was repeated in the thirteenth, fifteenth and seventeenth weeks. Each time during and immediately following the peeling there was marked tenderness and acute pain on striking or pinching any object; occasionally a throbbing sensation, more marked if the arms were hanging down, was felt in the affected fingers. The tenderness was so severe that it was difficult to button small buttons, or to tie or untie knots, such as shoestrings and necktie; in one instance a room mate's assistance was required in undoing a tightly drawn necktie. At present the skin of the tips of both thumbs and index fingers and small areas of the left middle and ring fingers are smooth and shiny, the ridges are flattened or absent, and the surface is cracked in appearance. When pressed on the flesh of these finger tips remains indented for an appreciable time. There is no apparent difference in vascularity as judged by their color.

"The index finger and thumb of the left hand, which is most affected, are distinctly tapering in contrast to the flat, blunt tips of the other fingers and to their own condition before June 1st. On fully extending these two fingers and to a less extent the index finger of the right hand, there is a marked pulling sensation at the junction of the flesh and the nail. The finger tips are at the present time only moderately tender."

CASE 5 (C. O. 15.24).—Assistant, medical student, began making routine applications of radium, July 4th, 1914. "First noticed slight tenderness in the tips of left thumb and index finger. This gradually increased to pain on touching objects. Otherwise there was no abnormal sensation. About August 8th, 1914, felt in the finger tips a very distinct pulsation which made it impossible to take the pulse for blood pressure estimation in the usual way. About this time a slight darkening of the color and numbness was noticed. This involved also the tip of the middle finger of the left hand. The tenderness disappeared, but the numbness increased until there was such marked anesthesia that it was impossible to button the shirt without looking because the buttonhole could not be felt with the forefinger or the button with the thumb. The finger tips when pressed on would retain the impression much longer than usual. About a week later a small white spot appeared on the tips and became almost 1 centimeter in diameter. This was picked off out of curiosity; it resembled a callus of the palms. The skin beneath was smooth, bright red to pinkish in color, dry and extremely tender. Three areas similar to this appeared. One cracked open, but there was no tendency to bleed. The tenderness was so great that it was necessary to bandage the fingers for a week, when the cracked area healed. On the three fingers of the right hand the superficial layer of skin peeled from the tip to the middle phalanx. At present date the fingers appear normal except for smooth glossy appearance and a tingling sensation which seems to spread over the whole finger tip when a small object such as the head of a pin is touched."

CASE 6 (C. O. 15.25).—Assistant, medical student, made no routine clinical application of radium, but on one occasion brought the day's supply of radium emanation from the physical laboratory to the hospital and thoughtlessly put the active tube in his pocket. "On July 28th, 1914, I carried a tube containing 32 millicuries of radium emanation in the left pocket of my trousers for about one hour. On August 4th, 1914, I noticed an irregularly oval red spot on the antero-lateral aspect of my left thigh. It was about 2 centimeters long and 1 centimeter wide. At this time there was no tenderness. The red spot gradually became tender, at first only to marked pressure and later to a slight touch. The skin in the center of this spot became yellowish, and by August 12th, 1914, there was a yellowish spot surrounded by a red border which faded into the surrounding normal skin.

"At this time the spot was very tender and felt warm. About August 15th the yellowish skin had scaled off, leaving a bright, glistening yellowish-red area which soon became covered with a crust. This was frequently rubbed off and reformed, each time being smaller, until September 5th, when the crust disappeared, leaving a smooth, somewhat glistening area a little more red than the adjacent skin and surrounded by a margin of slight pigmentation. September 28th the redness is gradually fading. December 16th the area is now smooth, white and there has been no tendency for the hair to grow out again."

CASE 7 (C. O. 15.26).—A physicist reports: "My first finger burns from the radioactive substances occurred 6 or 7 years ago, and I do not remember their symptoms in detail. They came from handling large quantities of emanation—from 200 to 250 millicuries.

"Since then six of my fingers have been burned six or seven times, severely enough for the skin to peel off. I have noticed the following symptoms in varying degrees of intensity: sensitiveness to pressure and heat lasting several days, sometimes so much that it becomes impossible to button buttons and hold warm eggs. Occasionally there has been continuous dull pain without pressure or heat. Each finger has been slightly red, with a small yellowish spot at the point of the most severe burn. After 4 or 5 days the pain and sensitiveness passed away and the fingers gradually become calloused. After several weeks the skin peeled off over a considerable area, leaving fresh skin that was quite sensitive for a few days. The lines that previously disappeared returned, and the finger tips were smaller than normal for a time, but gradually filled out. In no case has a finger ulcerated.

"There is sometimes a desire to hold the hands closed tighter than they usually rest. On the whole, my fingers appear to be less sensitive to touch, etc., than they used to be."

CASE 8 (C. O. 15.27).—A physicist devotes a part of his time in the laboratory daily to pumping the radium emanation into capillary glass tubes, and sealing these into lengths suitable for applicators. During this time the activity is comparatively slight, and they are retained in the laboratory 3 hours until the maximum intensity develops, when the measurement of the activity is made. "I so frequently burn the tips of my fingers while blowing glass that I was never quite certain during the early stages of a radium burn whether the pain was caused by a heat burn or a radium burn. The two sensations are, however, dissimilar. The pain of a radium burn is not at the surface; it is probably better described as 'soreness.' The nearest approach to it in heat burns are the burns caused by holding a glass tube which is just hot enough to cause a burn after 4 or 5 minutes. Radium burns, like heat burns, are sensitive to heat. I find it difficult to hold glass in the flame for glass blowing. Radium burns are more painful in the morning. I first notice them while dressing. The explanation of this seems to be that they are relieved by massage, manipulation of the flesh removing the soreness. As the burn progresses, the skin becomes hard and horny. The surface layers later peel off. It has seemed to me that as the burns are getting well, the burned tissue is not as firm as normal tissue; it feels as if there was a hollow space in the end of the finger. Up to March 26th, 1914, I have had seven burns."

CASE 9 (C. O. 15.28).—An assistant, medical student, reports: "On September 1st, 1914, I first began to use radium, but it was not until October 1st that I began to apply it daily in the routine work of the hospital. From then on to the present time I have done part of the outpatient work and some of the work on the house cases. The applicators used were of all sorts, steel tubes and flat applicators. Knowing the effects on others employed in radium application, I have been extremely careful throughout not to expose my fingers unduly, using forceps whenever possible. About December 1st I first began to notice some tenderness in the tips of the index and middle fingers and thumb of the left hand, but the index finger was more tender than the others (I am left-handed). A short while afterward the affected finger tips began to feel numb, and sensation was deadened as if a finger cot were drawn over each. The finger tips appeared red, when pressured they felt pulpy, and when the pressure was removed the skin remained depressed like parchment.

"During the last week of December I accidentally seared the tip of my left index finger with a match. The burn was slight and under ordinary circumstances would have healed in a few days. Contrariwise, in two or three days it began to peel, and by January 1st the whole palmar surface of the terminal digit and on the sides toward the nail had peeled, leaving a smooth, reddened surface which was exquisitely tender. It was especially sensitive to heat, warm water almost causing me to cry out in pain.

"Three days ago the left thumb showed a tiny break in the skin on the palmar surface toward the tip of the index finger. Within two days it had peeled off entirely, as did the index finger, and the symptoms were the same.

"I have had some relief by applications of 'white wash' left on over night.

"The fingers of the right hand show slight smoothing out of the papillae, especially on the thumb and index finger, but no redness or marked tenderness. The sensation of touch is numbed, but not to such a marked degree as in the left fingers.

"It is difficult to state just where to look for the errors in technic to bring about the above burns. At first I thought it might be caused by brief exposures when screwing the eyes into small unscreened steel tubes. The more likely cause, it seems, is in putting up special applicators or flat applicators, where it is almost necessary, under our present technic, to run one's fingers over the tube or to hold them while a piece of adhesive is being put in place."

COMMENT.

In these individual descriptions of the symptoms and signs, the similarity is striking. In certain instances, however, Cases 5, 6, 7 and 8, the injurious effects were due for the most part to acute reactions. In Cases 3 and 4 the changes were chronic with superadded acute, while in Cases 1 and 2 there were no acute burns, but the changes were the slow and insidious effect of repeated exposures. Indeed, in Case 1 there seems at the present time to be a peculiar susceptibility to slight exposure, even after a long interval in which radium has been but rarely handled.

Various general symptoms, such as headache, malaise, weakness, undue fatigue, unusual need of sleep, increased excitability, fretfulness, irritability, disorders of menstruation, attacks of dizziness, etc., have been said by Gudzent and Halberstaedter[3] to be caused by repeated and long-continued exposure to radioactive substances. Such symptoms are, however, common in many persons at times, and as they cannot be accurately and objectively recorded, there is doubt if they can be definitely proved to be due to exposure to radium. They may be due to close confinement, tiring routine and lack of outdoor exercise and other causes. The exposures of some of the cases reported were doubtless large; some were assistants in "fabriks" for manufacture of radium apparatus, and some had been engaged for years during the entire day in work with radioactive substances. It is probable, therefore, that certain general symptoms did occur as a result of this exposure. These symptoms, however, will not be considered in this paper.

Changes in the blood of radium workers were observed by Gudzent and Halberstaedter.[3] Most striking was the relative and absolute increase in lymphocytes: from 36 to 63 per cent; average of ten cases, 46.4 per cent; a relative and absolute decrease in neutrophils, average 50.3 per cent. There was little change in red blood corpuscles, slight diminution in white cells and the hemoglobin was lowered in only two cases, 70 and 71 per cent, respectively.

Although the changes are not striking in all instances, in Cases 1 and 7 the findings correspond with those mentioned above. In the other cases the changes are less marked, though suggestive. Case 4 (in which the assistant had just returned from a vacation away from radium exposure) and Control Case A under similar confining laboratory conditions, but not engaged in routine handling of radium, do not show such blood changes. Case 4 at a later time showed an increase in lymphocytes.

DETERMINATION OF SENSORY THRESHOLD.

Although the sensory changes in the affected fingers, as described above, were marked, it seemed desirable to check these up by a determination of the "sensory threshold" of the affected compared with the unaffected fingers. These determinations were kindly made by Mr. John P. Richards under the supervision and direction of Prof. E. G. Martin, who devised special electrodes for the finger tips for use with the Martin apparatus which has been previously described.[4] Dr. Martin reported that of the cases studied (Cases 1, 2, 3, 4 and 8), all except Patient 8, who was quite insensitive on all fingers, showed rather striking differences between the radiated and normal fingers, the former being much more insensitive. This relative insensitiveness to the faradic current might suggest injury to the nerve rather than to the terminal sensory end organs. It may, however, be due in some cases to increasing resistance of the skin because of thickening of the horny layer.

With the idea of determining whether demonstrable

[3] Gudzent and Halberstaedter: *Deutsch. med. Wchnschr*, March 26, 1914, p. 633.

[4] Martin, E. G.: Measurements of Induction Shock, New York, 1912.

histologic changes occurred in the chronically affected and relatively insensitive finger tips, October 7th, 1914, under aseptic precautions, without anesthesia, fragments of skin, including a portion of the corium, were excised with scissors from the tip of the right forefinger and little finger of Case 1; in the first instance there was very slight bleeding and little pain, while in the latter there was rather marked bleeding, soaking through a dressing, and considerable pain. The fragments were potted in Zenker's fluid. Both finger tips healed readily in a few days. Paraffin sections stained in eosin and methylene blue showed numerous nerves and terminal special sense organs. No marked difference was evident between the fragment from the control fingers by this technic, and specimens were not available for Weigert and Marchi methods.

AVOIDANCE OF INJURY.

Various methods have been devised, particularly by Dr. W. T. Bovie, for avoiding these injurious local effects by the least possible contact of the fingers with the radium. Forceps or special vises are used for holding tubes and screwing in or out the tips and eyes; special applicators in the form of metal boxes have been constructed so that the active tubes may be added after the filtration and protection have been arranged, and the surface applicator is then slipped by forceps into a special rubber envelope and fastened with adhesive. This is particularly to avoid wrapping them up by hand in sheet rubber. Leaded gloves, fingers, etc., are clumsy and are not readily worn.

In placing active tubes in special applicators, it will probably not be possible to avoid all contact with radium, and as the effects are not apparent at once, as when handling very hot objects, such as heated glass, but only after a period of days, or even weeks, it will be difficult to train a worker to avoid contact with the active apparatus.

In the work of making routine applications of radium there should be a routine in the staff, and persons affected should be freed at least temporarily from such work.

In order to avoid possible general disturbance, the body should be protected as far as possible by metal screens in form of boxes or plates about the radium; there should be frequent ventilation of work rooms, particularly if there is radium emanation present, and a change of duty, shorter hours and periodic physical examination of those working with radioactive substances with special reference to the blood examination is indicated.

SUMMARY AND CONCLUSION.

From the foregoing it is evident that marked changes may occur on the fingers of those engaged in routine work with radioactive substances. These local objective changes consist chiefly of flattening of the characteristic ridges, thickening and scaling of the superficial layers of the skin and even atrophy and intractable ulceration. These lesions are usually slight compared with the marked subjective symptoms, such as paresthesia, anesthesia of varying degree, tenderness, throbbing and even pain. Such effects is noteworthy.

Various general systemic symptoms and also blood changes may be produced by exposure to radioactive substances. To avoid such local and general disturbance, special protective and preventive measures have been devised, and those engaged in routine handling of radioactive substances are particularly cautioned.

Indian Music

THE Bureau of American Ethnology, under the Smithsonian Institution at Washington, has for many years been conducting most interesting researches among the American aborigines, or Indians, whose original habitat included this whole country, but is now limited to a few reservations. This once great and powerful race is rapidly becoming extinct, and but for the labors of this government bureau we would be ignorant of many of their interesting customs, arts and industries, as well as their history itself.

Among the researches carried on, a study of the music of the early owners of this continent is being made by Miss Frances Densmore. In this connection it was necessary to record results in such a manner as to make them available for reference, and many songs have been recorded phonographically, making a permanent and accurate record. These records are supplemented by abundant field-notes concerning the musical performers themselves, their surroundings and the circumstances under which the songs were rendered. As each song is studied and analyzed, the results secured are found to be much more than a simple collection of Indian songs. They include something of the human element, the singer's personality, as well as the technical analysis of his music, and its division into melodic and harmonic groups.

Music is a key to much of the ethnology of the people, especially to all that is sacred, their intimate feelings finding expression in the beauty, humanity and poetry of their songs. Thus far the study of Indian music has included five tribes, the Bureau of American Ethnology having already published two memoirs on Chippewa music.

In referring to the songs in general, Miss Densmore says that they "are not petrified specimens; they are alive with the warm blood of human nature." Music seems to be one of the Chippewas' greatest pleasures, expressing every phase of their lives. Some of the songs are generally known, while others are the property of a single person, and transferable only at his discretion, but usually sold. Visiting Indians take pleasure in learning new songs and bringing them home with them. Certain of the songs are to commemorate events, others pertain to ceremonies or initiations into societies, while others are connected with medicine, love, games and dances.

Miss Densmore has collected about 1,000 songs with the use of the phonograph, provided with a specially constructed recording horn and recorder. Great care in selecting the singers is always necessary to insure old and important songs; a good voice, as well as a free and natural rendition of the song, is desired.

A number of the songs secured from the Chippewas have to do with the belief in the Mide (Miday), or Grand Medicine, which is their religion and teaches many sound and practical doctrines; that long life is coincident with goodness, and that all evil inevitably reacts on the offender. The chief aim of the Mide is to secure health and long life for its adherents, and music forms an essential part of every means to that end. No reference to war and no allusions to enemies have been found thus far in the Mide. Among other things, the members of the cult are taught that their membership does not exempt them from the consequences of their sins. Lying, stealing and the use of liquor are strictly forbidden.

Naturally most of the songs are handed down and learned by ear, but great exactness is required in singing them. These particular Indians have a method of recording their songs in mnemonics on a strip of birch bark. The record, which is little more than a picture, serves as a reminder of the essential idea of the song, but leaves the words to the memory of the singer, or to his own ingenuity.

Besides the songs pertaining to the Mide initiations and ceremonies of the Chippewa, there are interesting songs relating to religion, war, social dances and daily life, healing of the sick, hunting and other occupations bearing upon the securing of food, and love. In the latter classification one song was sung in a coy and bashful manner by an elderly, withered and very dirty woman of the tribe, at Red Lake Reservation, who said the words meant, "What are you saying to me?" "I am arrayed like the roses and beautiful as they." This was a "charm song" of the Mide, and the diagram illustrating it crudely depicts the head, neck and trunk of a woman, with flowers blooming in her heart. No further information could be secured from this singer, as the next day she was threatened with calamity by certain of her sisters if she continued the singing. Later it was found that this song was known by other members of the tribe, located at White Earth, Minn., and a woman in that reservation recorded three other songs, completing a series of four.

A number of songs known as Dream Songs, collected on the White Earth and Lee Lake reservations, are said to have come to the minds of the Indians when they were in dreams or trances. These songs have a strong mental influence upon the Indians, to whom the supernatural is very real. No songs except those believed to be of supernatural origin were used in the treating of the sick, either with herbs or by the use of "jugglery." They were all believed to be essential to a cure, and could be sold by one "doctor" to another.

In treating the sick by means of "jugglery," a man demonstrated his supernatural power by strange feats, releasing himself from bonds in a manner not unlike the modern Houdini. This was done before he began the real treatment, and was in the nature of a "credential." He also related his dream and sang the song he received during it, the purpose being to inspire confidence in the patient. Indian treatment of the sick indicates a strong belief in the effect of the mind over the body, as evidenced by the constant use of affirmation; the "doctor" repeatedly assuring the sick man that he will surely recover.

Indian music, except for the songs of daily life, is closely associated with the supernatural, which is one reason why it is so closely guarded by them.

Ship Timber Making on the Pacific Coast

ON the Pacific Coast, where suitable timber is much more plentiful than in the East, ingenious special machinery has been developed for turning out various pieces used in shipbuilding. Prominent among these machines is the one that makes spars, which are in demand in all ports of this country, and abroad; and these spars can be made in any size, of perfect cylindrical section and tapered as desired. Square or hexagonal spars can also be turned out, and by means of a sandpapering machine the finish is most perfect. Another special machine is one that turns out ship planking, accurate in shape, with bevel and calking seam in one operation. Everyone who knows the old methods of getting out ship planking will appreciate what a great saving of labor such a machine effects, and in addtiion it produces more accurate work.

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